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ANNUAL REPORTS

OF THE

WAR DEPARTMENT

FOR THE

FISCAL YEAR ENDED JUNE 30, 1904.

VOLUME X.

REPORT OF THE CHIEF OF ORDNANCE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1904.

ARRANGEMENT OF THE ANNUAL REPORTS OF THE WAR DEPARTMENT FOR THE YEAR ENDED JUNE 30, 1904.

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- Inspector-General.
- Judge-Advocate-General.

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REPORT OF THE CHIEF OF ORDNANCE.

OFFICE OF THE CHIEF OF ORDNANCE,
UNITED STATES ARMY,
Washington, October 27, 1904.

SIR: I have the honor to submit the following report on the principal operations of the Ordnance Department during the past year, together with certain remarks as to its interests and necessities:

WORK OF ORDNANCE ESTABLISHMENTS.

The Ordnance Department is charged with the duty of designing, manufacturing, and otherwise procuring, and of supplying to the service, and maintaining in repair the artillery, small arms, ammunition, and personal and horse equipments for the fixed defenses and the mobile armies and militia of the United States and its insular possessions; and by authorization supplies, also, practically all of the small arms and equipments of the Navy and the Marine Corps. In this work it employs over 5,000 workmen in six great establishments, which are guarded and generally cared for by 700 enlisted men. Much of the work of the Department is of a scientific character, involving the application of the sciences of chemistry, mechanics, and electricity. The amount of this class of work is difficult to set forth accurately, but it will help in forming an estimate of it to know that of the high-class aids to such work known as draftsmen, who translate theoretical study into the specification and illustration which precede production, there are employed 61. An imperfect general measure of the work of a department of construction and supply is furnished by the amount of funds which is expended by the Department in carrying the work on. For the last four years this amount has averaged for the Ordnance Department over $13,000,000 annually, or more than $187,000 per officer. As the work has been done by practically the entire corps, the latter figures give a kind of representation of the amount of responsibility which has, on the average, fallen to each officer, expressed financially.

The present establishments of the Ordnance Department, with their location and uses, are as follows:

Watertown, Mass., manufacturing arsenal.
Springfield, Mass., manufacturing armory.

Watervliet, N. Y., manufacturing arsenal.
Governors Island, N. Y., arsenal of storage, issue, and purchase.
Sandy Hook, N. J., proving ground.
Dover, N. J., powder depot.
Philadelphia, Pa., manufacturing arsenal.
Augusta, Ga., arsenal of storage and repair.
Rock Island, Ill., manufacturing arsenal.
San Antonio, Tex., arsenal of storage and repair.
Benicia, Cal., arsenal of storage and repair.

All of them are used for the issue of supplies, and all of the manufacturing arsenals are also arsenals of storage and repair.

The principal although not the sole manufacture of each of the manufacturing establishments is as follows: Of the Watertown Arsenal, seacoast gun carriages; of the Springfield Armory, small arms; of the Watervliet Arsenal, cannon, large and small; of the Frankford Arsenal (Philadelphia, Pa.), ammunition for small arms and mobile artillery; of the Rock Island Arsenal, personal and horse equipments, carriages for mobile artillery, and small arms. All of the muskets, small-arm ammunition, and personal and horse equipments required for the Army are manufactured by the Department, but of other classes of ammunition and small arms, of small cannon, and of gun carriages a considerable proportion of the requirements of the service is supplied by private establishments.

At the invitation of the American Society of Civil Engineers the following papers, showing the progress made in this country during the last decade in the science and art of different branches of ordnance engineering, were prepared by officers of this Department for the International Engineering Congress, held October 3 to 8, at the Louisiana Purchase Exposition, viz: Capt. John T. Thompson, small arms; Capt. George W. Burr, mobile artillery; Capt. Odus C. Horney, seacoast guns; Capt. Thales L. Ames, ammunition for cannon; Capt. Edward P. O'Hern, seacoast gun-carriage design and construction.

PERSONNEL.

In my previous reports I have invited attention to the disadvantageous condition of the Department in regard to its personnel. I must now repeat the statement that the Department can not do its work with its present force of officers. Those who are now carrying on the operations of the Department are worked to such an extent as to interfere with the quality of their product, and the quantity and character are below what is necessary if the Department is to do what is expected of it. The present authorized strength, 71 officers, is less than the number which it is thought can be readily shown to be necessary, and there is a shortage of 16 officers below the number authorized. Officers of the ability needed and called for by the character of the examinations exist in quite sufficient numbers in the service, but there is no inducement to tempt them to fit themselves for duty in the Ordnance Department, and to perform the arduous work consequent upon service therein. If such legislation is not enacted as will enable the Department to stimulate and utilize the talent which exists in the service, either civilian engineers of proper attainments, at corresponding salaries, must be employed or the financial resources of the Department must be so expended as to bring into existence a properly skilled corps of experts in the employ of private manufacturers.

The consequence of the present condition is that, notwithstanding the devoted efforts of its officers, the business of the Ordnance Department is now carried on with only fair efficiency. In every case of lapse, investigation leads ultimately back to the same cause, lack of officers. The engineering and designing work is lagging badly; much is being pursued, but much is also being left undone. To the eye of responsible concern the latter presents disquieting prominence.

A measure of relief has been submitted by the undersigned and, after modification resulting from discussion, has been approved by the General Staff, the Chief of Staff, and the Secretary of War. With some further modification it is now before the Senate with favorable report from the Committee on Military Affairs of that body. It is hoped that it may speedily become law.

FISCAL AFFAIRS.

The fiscal resources and expenditures of the Department during the year were as follows:

Amount in the Treasury to credit of ordnance appropriations on July 1, 1903	$11,010,045.84
Amount deposited in the Treasury on account of the Ordnance Department, but not credited to ordnance appropriations, on July 1, 1903.	36,315.78
Amount in United States depositaries to credit of disbursing officers under ordnance appropriations on July 1, 1903	1,554,354.36
Amount of appropriations made for the fiscal year ending June 30, 1904, including the amount of those contained in the act making appropriations for fortifications and other works of defense, etc., approved April 21, 1904, under control of the Ordnance Department.	10,245,613.41
Amount refunded during the fiscal year ended June 30, 1904, to ordnance appropriations by Treasury settlements, on account of transfers of property to the various bureaus and Executive Departments, to the organized militia, etc	2,245,885.16
Amount received during the fiscal year ended June 30, 1904, from sales of ordnance and ordnance stores; from collections from troops on account of loss of or damage to ordnance stores; from Chicago, Rock Island and Pacific Railroad Company on account of maintenance of Rock Island Bridge; proceeds arising from tests made by the Government testing machine at Watertown Arsenal, and from other sources not before mentioned	162,535.30
Total	25,254,749.85

Amount disbursed by disbursing officers from ordnance appropriations during the fiscal year ended June 30, 1904	$9,657,329.54
Amount paid and transferred by Treasury settlements during the fiscal year ended June 30, 1904, from ordnance appropriations on account of transfers of property from other Bureaus and Executive Departments to the Ordnance Department, and of payment to contractors for certain purchases, etc	100,231.33
Amount deposited in the Treasury during the fiscal year ended June 30, 1904, and credited to "Ordnance material (proceeds of sales)"	69,275.02
Amount covered into the Treasury under "Miscellaneous receipts" on account of proceeds of Government property during the fiscal year ended June 30, 1904	3,479.48
Amount covered into the "Surplus fund" of the Treasury on June 30, 1904	71,203.54
Amount in United States depositaries to credit of disbursing officers under ordnance appropriations on June 30, 1904	1,585,583.72
Amount deposited in the Treasury on account of Ordnance Department, but not credited to ordnance appropriations, on June 30, 1904	11,694.49
Amount in Treasury to credit of ordnance appropriations on June 30, 1904	13,755,952.73
Total	25,254,749.85

The above statement comprises not only the appropriations made exclusively for the service of the Ordnance Department, but also those made for experiments conducted under the direction of the Board of Ordnance and Fortification, and for the purchase of submarine mines, the control of which rests with the Chief of Artillery. These appropriations are entitled "Board of Ordnance and Fortification" and "Submarine mines," and the amounts appropriated under each heading at the last session of Congress was $100,000. A record of the amounts appropriated, allotted, remitted, and expended under each of these appropriations is kept on the books of the Ordnance Office; in the case of the appropriation "Submarine mines," the disbursements made under it receive the administrative action of this office, but for the appropriation "Board of Ordnance and Fortification," such administrative action is only had on disbursements under allotments made specifically for expenditure through the Ordnance Department.

TRANSFERS OF ORDNANCE STORES TO THE EXECUTIVE DEPARTMENTS AND THE ORGANIZED MILITIA OF THE SEVERAL STATES.

The value of stores thus transferred is refunded to ordnance appropriations by Treasury settlements on presentation of evidence showing the transfer. The value of the stores transferred to the Navy for which this Department was reimbursed amounted to $205,669.69; to the Marine Corps, $42,996.17; to the other Executive Departments, $9,940.32, and to the organized militia, $1,930,912.66. In conducting experiments for the Board of Ordnance and Fortification, the value of the ordnance stores which were used in them amounting to $26,541.69

was transferred from the appropriations for the Board to the ordnance appropriations proper. The total amount by which ordnance appropriations were credited on account of Treasury settlements amounted to $2,245,885.16, as shown in the statement. This amount is equivalent to very nearly 25 per cent of the amount appropriated for this Department and shows that the work of the Department for other objects than those of arming, equipping, and supplying the regular Army was nearly 25 per cent of the latter—measuring the work done by the money available for it. This does not take into consideration sales to the Philippine civil government and direct sales to the organized militia, which do not appear in Treasury settlements.

DISPOSITIONS OF FUNDS RECEIVED FROM TRANSFERS, SALES, ETC.

Prior to April 23, 1904, the proceeds arising from transfers and sales of serviceable ordnance stores were credited to the several appropriations out of which they were procured, except in cases of transfers to the militia authorized by section 1661, Revised Statutes, the cost of which was credited to the appropriation for the "Manufacture of arms." By the act of Congress approved April 23, 1904, it is authorized that all funds arising from such transfers and sales authorized by law shall be credited to one fund, which has been denominated, "Replacing ordnance and ordnance stores," which shall be available throughout the year in which the transaction was effected and the following year, to replace the supplies transferred or sold. This provision of law applies not only to Treasury settlements, but also to sales which result in depositing the proceeds in the Treasury.

DISBURSEMENTS.

The disbursement made directly by disbursing officers and the payments made by Treasury settlements from ordnance appropriations amounted to $9,757,560.87. The amounts of the disbursements made at the principal arsenals during the fiscal year and in the Ordnance Office are as follows:

Frankford Arsenal	$1,784,064.74
Rock Island Arsenal	2,688,301.04
Sandy Hook Proving Ground	209,516.02
Springfield Armory	1,482,441.18
Watervliet Arsenal	705,165.93
Watertown Arsenal	660,471.27
Ordnance Office	1,366,131.39

AMOUNTS COVERED INTO THE SURPLUS FUND.

The principal amounts covered into this fund were $12,878.54 under the appropriation for small-arms ammunition for the fiscal year 1902; $9,392.81 under an appropriation for a magazine at the powder depot, which has been completed; $15,000 under an appropriation of that amount for torpedo howitzers now of an obsolete type; $2,500 appropriated July 23, 1892, for the expenses of a board to select a site on the Pacific coast for a gun factory, and $12,231.63 under several appropriations for the armament of fortifications, the improvements in the design of material rendering the objects authorized no longer required.

COMPARISON OF THE FISCAL STATEMENT WITH THAT OF THE PRECEDING YEAR.

Comparing the fiscal statement with that of the preceding year, it will be found that the amount of the appropriations for the year was increased $600,722.40, and the amount of disbursements and payments by $536,179.50. The amount received on account of transfers to the Executive Departments and the organized militia increased from $763,420.48 to $2,245,885.16, a gain of $1,482,464.48. This increase arose largely from the rearming and equipping of the militia. The increase of the amount available on June 30, 1904, for disbursement over that available July 1, 1903, amounting to $2,751,464.62, arose from the increase of refundments by Treasury settlements and of appropriations and to a decrease of $180,082.94 in the amount covered into the surplus fund of the Treasury.

SALES TO THE PHILIPPINE CIVIL GOVERNMENT.

In my last annual report I referred to an indebtedness of $119,229.33 due this Department by the Philippine civil government on account of arms, ammunition, and equipments furnished it for the use of its constabulary. By a provision of law contained in the act of Congress approved April 23, 1904, that Government was relieved of this indebtedness and the account ordered closed.

REDUCTION OF APPROPRIATION HEADINGS.

In my last annual report I referred to the importance of a reduction in the number of appropriation titles under which this Department is compelled to account for the various expenditures made by it. Recommendations to this effect were made to the various committees of Congress which have supervision over the appropriations made for the Department, and the results have been partially successful. The number of appropriations for this Department which are generally made in the act for the support of the Army, excluding the appropriations for the militia, were reduced from 10 to 7, and it is proposed to make recommendation to Congress with a view to making a further reduction. The number of appropriations contained in the act for fortifications and other works of defense were reduced from approximately 58 to 12, and the new appropriation titles cover objects which naturally should be classed together in order that Congress might have some idea, in a general sense, of the amounts expended for these purposes.

Briefly speaking, the new appropriations for armament of fortifications provide for specific appropriations for machine and automatic guns; for mountain, field, and siege guns, including their carriages; for seacoast guns and their carriages; for artillery target practice, etc. At the last session of Congress provision was made for fortifications in the insular possessions, and as Congress has chosen to provide for these separately, it has led to an increase in the number of appropriations, but there is no way of avoiding this increase. It was hoped that the Committee on Appropriations would look favorably upon a recommendation leading to accounting for all appropriations made for a specific object at the various arsenals under one heading, but this recommendation failed to meet with the approval of the committee. By consolidating estimates, as submitted to Congress, for the various objects at the arsenals, it was expected to reduce in this way the number of appropriation titles.

PAYMENT OF EMPLOYEES.

At the last session of Congress, on the recommendation of this Department, Congress enacted a provision of law providing for a uniform system of computing payments due employees drawing annual salaries. This remedied the difficulty referred to in my last annual report, wherein one class of employees of the Department was paid on one basis and another class on another basis.

PURCHASES.

During the last session of Congress a provision of law was enacted relieving this Department from reporting all open-market purchases under $100. The same provision of law also authorized the Department to procure services in the open market up to and including $200. This new provision of law saves considerable clerical work, which fulfilled no real purpose, and besides authorized the procurement of services, when the amounts were small, in a manner common among business men.

RECENT LEGISLATION AFFECTING DISPOSITION OF FUNDS ARISING FROM SALES OF SERVICEABLE ORDNANCE STORES.

In my last annual report it was shown how much clerical work was involved in crediting the numerous and various appropriations in this Department, when stores procured under these appropriations were transferred to Executive Departments, to the militia, etc. It was recommended to Congress that the funds arising from such transfers, as well as from sales, should constitute one fund on the books of the Treasury Department, and the following legislation was enacted by Congress:

> Hereafter all moneys arising from disposition authorized by law and regulation of serviceable ordnance and ordnance stores shall constitute one fund on the books of

the Treasury Department, which shall be available to replace ordnance and ordnance stores throughout the year in which the disposition was effected and throughout the following year.

This provision of law enables this Department to furnish supplies to any of the Executive Departments at any time during the fiscal year with the certainty that the value of the supplies will not be deducted from the sums which Congress has directed to be applied to the purposes of the War Department.

The importance of this legislation is further evidenced from the fact that from the date of its approval, namely, April 23, 1904, until June 30, 1904, the sum of $190,935.72 was transferred to this fund. At the coming session of Congress recommendation will be made that not only funds arising from disposition referred to above shall be credited to this fund, but that all losses or damage to ordnance stores by railroad or transportation companies shall be credited to the same fund. It is obvious that when property is lost in transportation without having carried out the purpose for which Congress intended it, the money value of the same, when collected from the transportation company, should be used to replace the property so lost in order that the intent of Congress may be carried out.

BLANKS.

In my last annual report I referred to the importance of simplifying the blanks to be used in the executing and rendering of accounts for public funds. All the blanks in use by the Department for rendering money accounts, making reports in connection therewith, etc., have been prepared so that all of them can be executed on a typewriter in as many copies as may be desired. Instructions in each case have been printed on the back of each blank for the guidance of the person who may be called upon to execute them. This change has resulted in a reduction of fully 75 per cent in the amount of correspondence with the various disbursing officers of the Department concerning the execution and accomplishing of money vouchers and other papers.

EXAMINATION AND SETTLEMENT OF PROPERTY RETURNS IN THE ORDNANCE OFFICE.

The simplifications begun in 1899 in the manner of rendering the property returns and the methods of dealing with them in the Ordnance Office have produced their full effect in the last year, during which the work on back returns has been entirely completed. It has seen the last remnant of the volunteer returns settled, and has had to deal for the most part only with returns from the Regular Army, which are much less complicated than before, owing to the greater experience of the officers and the clearer definition of their responsibilities.

Dealing only with officers of the regular establishment, it became possible during the last year to apply more rigidly the penalties for failure to promptly render property returns and make explanation for errors, and rigidly enforcing stoppages of pay because of such neglect has resulted in much greater prompitude in the settlement of accountability.

In settling the final accounts of officers great benefit has resulted from the arrangement, long desired and recently effected with the Auditor, by which final accounts against an officer are not held open indefinitely, but the amounts not accounted for by him are deducted from his final pay and the responsibility balanced on the books of the office.

The reduction in clerical force has borne out the promise made at the time the improvements in methods were brought about. During 1899 the clerical force for this division amounted at one time to 52 clerks. This has now been reduced to 14.

During the last year this division of the office has for the first time had the benefit of the law providing, as recommended in report of Chief of Ordnance for 1900, for the rendition of returns semiannually instead of quarterly, reducing by over one-third the number of returns needing to be examined annually. This has been a relief both to the Ordnance Office and to officers rendering the returns. The returns rendered under this system are larger, but there is a saving of time on the whole because there are fewer totals to be carried forward, and it is practicable to examine all the returns received before the next returns come in.

In the report of the Chief of Ordnance for 1899, reference was made to the necessity for sacrificing the examination of returns to the demands of the work of the office, particularly to that of Manufacture and Supply, which could not be postponed. The nominal force of clerks in this division scarcely ever represented the number wholly engaged on returns. So many were drawn away for other work in the office that the clerk in charge could never count on the continued service of all the force. Repeated efforts were made to secure a permanent body, even if smaller in number, that would not be subject to frequent and unexpected calls to other work, and the beneficial results of such an arrangement were prophesied, but it was only during the last year that the more settled condition of affairs allowed this to be accomplished.

The report of the Chief of Ordnance for 1900 urged the abolition of boards of survey composed of several officers and the substitution of a survey officer corresponding to a field officer's court. The New Army Regulations have brought this about, and good results are anticipated from the change in reducing papers requiring examination in settling officer's returns.

In the same report the Chief of Ordnance recommended the simplification of papers relating to transfer of ordnance property when placed in the hands of detached soldiers sent from one station to another. This was adopted for the Medical Department the next year and for the Signal Corps soon after, and its application to the entire service has just been made a part of the Army Regulations. This avoids the transfer of formal receipts between officers when the destination of detachments is unknown, and saves delay in obtaining receipts as vouchers for the returns.

The field blanks, of pocket size, introduced by the Department in 1899, have proved of advantage to officers in campaigning, and several recommendations of the Department and its officers have tended to reduce delay and produce simplification. Particularly is this the case in the Philippines in giving the division commander power to make contracts, approve bills for printing and advertising, order sales of condemned property, and authorize transfer of stores between different departments or bureaus. All these changes make the adjustment of accountability more direct and simple.

At the end of the year only 251 returns remained unsettled, these settlements being delayed for want of proper explanation by officers rendering them, without which explanation it was impossible for this office to close them.

The work of the office as tabulated in the manner given in previous reports of the Chief of Ordnance is as follows:

	Number of returns not closed June 30, 1903.	Number of returns received.	Total.	Acted on during year.		Number of returns not closed awaiting correspondence June 30, 1904.
				Finally examined.	Closed.	
Arsenals and inspectors	20	52	72	54	61	11
Regular Army	3,431	5,986	9,417	8,408	9,177	240
Volunteer Army	12	4	16	4	14	
Spanish War Volunteers	2		2			
Total	3,465	6,042	9,507	8,466	9,256	251

CONDITION.

Awaiting final examination, June 30, 1903	2,424
Awaiting result of correspondence, June 30, 1903	1,041
Total	3,465
Awaiting final examination, June 30, 1904	None.
Awaiting result of correspondence, June 30, 1904	251
Total	251

DETAILED STATEMENT.

Closed	9,256
Examined	8,466
Settled by correspondence	790
Awaiting result of correspondence, June 30, 1903	1,041
Awaiting result of correspondence, June 30, 1904	251
Awaiting final examination, June 30, 1904	None.
Total	251

In the work of this division of the office very great assistance is derived from the practice of having a preliminary examination made at the Manila Ordnance Depot of all returns rendered by officers in the Philippines. This saves the delay of waiting until returns can be sent to Washington and there examined, leaving the officers long in doubt of the result of the examination, and it enables the Ordnance Department to correspond promptly with officers who make the returns and notify them of errors and omissions. It also relieves the Washington office of much of the routine work of examination, since the results are all outlined before the returns are received. In this way is hastened the settlement of accounts which would otherwise involve much difficulty. The following is a summary of the work done at the Manila Ordnance Depot under charge of the chief ordnance officer of the Philippines Division during the fiscal year:

Returns on hand July 1, 1903:		
Unexamined	773	
Examined and held for correction	111	
Examined and held for comparison	228	
Total		1,112
Returns received during the fiscal year		1,630
Total		2,742
Returns sent to the Chief of Ordnance		2,207
Total on hand July 1, 1904		535
Total of these held for correction	82	
Total of these held for comparison	423	
Total number examined	30	
		535
Letters received		4,127
Letters sent		3,294
Indorsements sent		1,536
Indorsements received		1,279

During the year this division was first under charge of Maj. L. L. Bruff, and later under charge of Maj. H. D. Borup, Ordnance Department, under both of whom the work of the office was continued, and to the energetic administration of the latter (since retired from the service at his own request) is due the final closing out of all back returns.

At the close of the year the reduction of work in the division, with the corresponding reduction of clerical force, has made it possible to transfer the property division back to the War Department building from the detached building previously occupied by it since 1898 at the corner of G and Eighteenth streets. The inconvenience of having the clerical force of the Ordnance Department separated has been pointed out in previous reports, and the consolidation will greatly simplify the work of this division in its relations with the other divisions of the office, though the room allowed is hardly enough for full efficiency.

SANDY HOOK PROVING GROUND.

The proving ground was commanded during the year by Lieut. Col. Charles S. Smith, Ordnance Department.

Firings for experimental and proof purposes have been conducted daily, weather permitting.

The following material received at the proving ground has been subjected to ballistic test:

29 lots of projectiles.
8 lots of shrapnel.
44 guns.
89 lots of powder.
7 lots of fixed ammunition.

The firings during the year have involved an expenditure of 154,660 pounds of powder, a total of 7,655 rounds having been fired.

The railroad, by means of which the proving ground is connected with all points outside, has proved a source of convenience and economy, confirming the original estimate as to the advisability of its purchase and maintenance.

In accordance with recommendation of a board of officers convened at Sandy Hook, N. J., November 5, 1903, an allotment of $75,000 was made by the Quartermaster-General for the construction of a new trestle on the narrow neck of land connecting the reservation with the mainland. The work has been taken up and the contract has been awarded for its construction, the work to be completed by November 15, 1904. About 400 feet of effective sidings have been provided and connections made with the old trestle at a point about 650 feet from the southern end. It is proposed to put this 650 feet of the old trestle in condition to be used as a freight siding.

As soon as the contemplated repairs to the sea wall have been made, the section of the old trestle, which will have been converted into a freight siding, can be filled in with sand and ballast and a grade track made. This can not be done until the sea wall is constructed, owing to the fact that at high water this section of the neck is overflown. The total amount of freight shipped over this railroad during the year amounted to 24,087,404 pounds, requiring a total car movement of 627 cars. The total number of passengers carried during the year was 161,625.

Instruction of officers.—It has not been practicable during the year to specify regular hours for the instruction of officers in the school of application, owing to the requirements of other duties at the proving ground. The progress of the officers has, however, been satisfactory, as far as it relates to their interest and zeal, and it is hoped that when the difficulties under which the Department is now laboring, owing to the lack of personnel, are removed plans looking to more systematic instruction may be consummated.

Machine-shop work.—The work for the officers in machine-shop practice is prescribed in orders, and each officer is expected to complete the work allotted during the year. When there has been a failure to meet the requirements of this work it has generally resulted from the assignment of other work interfering. Much interest has been taken in this work and the student officers have been much benefited by it.

Department of electricity.—All of the student officers do practically the same amount of work in this department during the year. The average per week was about three and one-half hours' study and one and one-half hours' practical work. For the ensuing year the practical work prescribed has been materially increased and the theoretical work slightly decreased. It is estimated that the new course will require about one hundred and fifty hours' study and three hundred hours' practical work, making an average of about nine hours per week for the year.

Chemical laboratory work.—No complete schedule has been prescribed as yet for work of the student officers in the chemical laboratory. During the past year the chemical apparatus and the standard test of powders and explosives were explained and illustrated. The student officers also visited the works of the International Smokeless Powder and Chemical Company, at Parlin, N. J., where they were courteously received, and enjoyed an opportunity to witness the manufacture of smokeless powder in all its details. After becoming acquainted with the standard tests and acquiring practical efficiency in conducting them, officers are expected to engage in investigating work, for which the equipment of the laboratory at the proving ground is well adapted.

In the interior ballistic formulæ now available, the powder constants, such as the force of the powder, its co-volume, its rate of burning under atmospheric pressure, and the exponent of the power of the ratio of pressures in the expression of the rate of burning as a function of pressure have been combined into one or more general constants, whose values have been determined from normal ballistic data.

These formulæ do not permit the separation and study in detail of the action of the constants enumerated above, and hence do not give a satisfactory explanation of abnormal ballistic results. Capt. B. W. Dunn, of this Department, has been in charge of the chemical laboratory and has been assigned as a subcommittee of the Ordnance Board to the special duty of studying smokeless powder. He has developed formulæ which are designed to meet this deficiency and to permit an estimate of the effect of a change in any single condition in loading or in any well-defined characteristic of the powder. It is regretted that the limited personnel of this Department has not permitted the assignment of more officers to work exclusively in this field.

Shops.—The shops in this place, while primarily occupied in connection with proving-ground work, have in addition much work in the repair and alteration of the armament in the Central and Sandy Hook armament districts. It has been necessary during the year to add a few new tools and to employ additional mechanics. It is proposed, as soon as funds are available, to equip several machines in these shops with individual motors in order to save power which is now lost in driving line shafting when the machines are not in operation.

Proof battery.—A plan for changing the location of armor-plate backings and for improving the method of handling velocity screens is under consideration. It has been found essential to provide means for taking velocities when firing at plates, and to do this satisfactorily these backings must be moved farther from the emplacements. The plan contemplates two or three light railway tracks running parallel to the line of emplacements at the battery. Small cars will carry the velocity screens along the tracks to the position desired. The armor-plate backings will be located beyond the screens, and the runs which carry the chronograph wires will be placed underground to prevent their being cut by fragments of plate or shell.

New construction.—The new brick storehouse authorized by the fortification act approved June 6, 1902, and the brick magazine for fixed ammunition, authorized by the sundry civil act approved March 3, 1903, are under construction and will be completed during the year. The storehouse is located so as to provide for both railroad and cart transportation. The magazine will furnish storeroom for fixed ammunition, and a separate room is provided for the storage of fuses and primers. Plans for the locomotive shed, authorized by the sundry civil act approved April 28, 1904, are now being prepared, and the erection of the building will be undertaken and completed during the year.

A shed has been erected for the storage of armor-piercing projectiles, and it is thought possible that a cover will also be required for the storage of other projectiles on hand at this place. Plans for the bombproof for the protection of observers on the firing range, and the observation range and plotting tower, authorized by acts of Congress, are now being prepared.

SMALL ARMS.

United States magazine rifle, model of 1903.—Immediately upon the approval by the Secretary of War, on June 19, 1903, of the adoption and manufacture of this arm, instructions were given to the commanding officer of Springfield Armory to make the necessary fixtures, tools, gauges, templets, etc., for the manufacture at that armory of 400 arms per day of eight hours, and for the manufacture at Rock Island Arsenal of 125 arms per day of eight hours. Sufficient fixtures, gauges, etc., were completed in the early part of the present calendar year to enable a daily output of 300 rifles to be obtained at the Springfield Armory, which output, it is anticipated, will be increased by November 1, 1904, to 400 per day. The greater part of the fixtures, gauges, etc., for the Rock Island Arsenal have been completed and installed, and the manufacture of rifles has begun. It is anticipated that a regular daily output of 125 arms will be obtained at the latter plant before June 30 next.

Upon the approval of the Chief of Staff, United States Army, the Corps of Cadets, U. S. Military Academy, West Point, N. Y., was equipped with the new rifle on March 23, 1904. As the cartridge for the new is different from that of the old rifle, it has been decided to make no other issues of the former arm, except in Alaska, China, and the Philippines, until a sufficient number have been completed to enable the entire Regular Army to be equipped at the same time. It is anticipated that this exchange of arms can be made in January next.

As the result of a series of tests, such minor details as the form of the striker point and the amount of its projection beyond the face of the bolt, the strength of the sear and main springs, and the twist of rifling have been determined; a number of minor changes have also been made in some of its parts.

The following appendages have been designed and will be furnished with the new rifle, namely: Muzzle and front sight cover, screw-driver and combined oiler and thong case. The latter is carried in a receptacle in the butt of the stock; one-half of the case contains oil and the other a thong and brush for cleaning the bore.

For the purpose of determining that twist which would give the greatest length of life of the barrel, consistent with accuracy and stability of the bullet, firings were conducted with barrels rifled with a uniform twist of one turn in 8, 8½, 9, 9½, 10, and 11 inches. The results of these firings indicated that the 8-inch twist gave greater accuracy than the longer twists, but that after a number of rounds had been fired the accuracy with the 8-inch twist decreased much more rapidly than with the longer twists. After firing 3,000 rounds, the accuracy of the 8-inch twist decreased 30.7 per cent, and that of the 9-inch twist, 25.1 per cent. After firing 6,223 rounds with the 8-inch twist, the rifling was practically worn out, while after firing 6,073 rounds with the 9-inch twist its accuracy had decreased only 56 per cent.

As calculations show that a uniform twist of one turn in 10.5 inches is sufficient to insure stable flight of the bullet, a uniform twist of one turn in 10 inches was adopted.

The experience had during the experimental firings conducted for determining the accuracy, drift, etc., of this rifle, indicates that, due to erosion of the bore at the bullet seat by the powder gases and to the wearing of the lands of the rifling, the accuracy of the barrel begins to diminish after firing from 1,600 to 2,000 rounds. As the energy of recoil may prove sufficiently great to make raw troops flinch in firing, it may be found advisable to make a slight reduction in the muzzle velocity of the rifle, which reduction can be made and still leave this arm more powerful than those in general use in foreign military services.

Tables showing the number of spare parts prescribed for issue to regimental and post ordnance officers for repairing the new rifle in the hands of troops, and to ordnance depots established in time of war, and the number of spare parts to be made with each 1,000 completed arms for storage until required in time of war, have been adopted. The spare parts for the latter purpose will be packed in special boxes for storage.

A special form of chest has been made for issue to post ordnance officers of posts at which not less than two battalions of infantry or two squadrons of cavalry are stationed to insure the safe-keeping and better care of spare parts.

United States magazine rifle, model of 1898.—The output of United States magazine rifles, model of 1898, was gradually decreased as that of the new rifle was increased, until its manufacture ceased entirely in November, 1903. As the United States magazines rifles and carbines of the models of 1896, 1898, and 1899 were provided with five different models of rear sights, viz, models of 1892, 1896, 1898, 1901, and 1902, a sufficient number of model of 1902 sights are being manufactured to replace the models of 1892 and 1896, and all model of 1898 sights are being altered to the model of 1902, thus reducing the number of different models from five to two. The addition of the plate containing the peep-sighting notch constitutes the principal difference between the models of 1898 and 1902. As these arms are replaced with the new rifle, they will be thoroughly overhauled, cleaned, and stored as a part of the reserve supply.

The District of Columbia and all the States and Territories, except Nevada and New Hampshire, have been supplied, practically to full authorized strength of their Militia, with this old magazine arm of Krag-Jorgensen type.

Revolver.—As experience had in actual service with the present service caliber .38 revolver showed that its bullet does not possess sufficient stopping power and shock effect, experiments were undertaken for the purpose of ascertaining what design and caliber of bullet possesses these essential features. When these experiments are completed advantage will be taken of the change in cartridge, should such a change be necessary, to definitely decide, in view of the experience had with automatic pistols in the hands of troops, whether any design of that class of weapon has reached that stage of perfection to warrant its substitution in service for the revolver.

The subject of the automatic musket is in about the same state as described in my last annual report, although it is anticipated that more than one design will be ready for test during the coming year.

Automatic machine guns.—As the tests made by the Department during the past several years indicated that several different designs of automatic machine guns had been brought to a practical working stage under service conditions, a board of officers, of which Capt. Edwin V. Bookmiller, Ninth Infantry, was president, was convened by the War Department, August 20, 1903, for testing such automatic machine guns, mounts, and pack outfits as might be referred to it from this Office. As soon as the design of ball cartridge, model of 1903, was completed, all American and foreign inventors of this class of arms were invited to submit their devices for test. The following were submitted and tested by the board, namely: Colt's automatic machine gun, tripod mount, carriage, and pack outfit; Danish rifle mitrailleuse and tripod; Vickers' Sons & Maxim solid action and standard pattern guns, tripod mount, galloping carriage and sleigh mount, and pack outfit.

The recommendation of the board that, as a result of the thorough and exhaustive tests to which the four guns were subjected, the Vickers' Sons & Maxim standard pattern automatic machine gun, tripod, and pack outfit be adopted for issue to field troops, and the same gun, on a broad-tired wheel mount, be adopted for issue to seacoast forts, was approved by the Secretary of War on November 10, 1903.

The report of the board forms Appendix No. I hereto.

Ninety guns, tripod mounts, and pack outfits are now being manufactured, and funds are available for the purchase of 30 additional guns, tripods, and pack outfits for field troops, and for 30 guns and wheel mounts for seacoast forts. As no satisfactory form of wheel mount could be obtained, it is being designed by Capt. W. S. Peirce, Ordnance Department, at the Springfield Armory. It is intended for field service that pack transportation should be provided for 7,000 rounds of ammunition for each gun, which requires the use of 5 mules, loaded as follows: One with the gun, tripod, 3 ammunition boxes, spare lock, feed block, and counter recoil spring; a second with 7 ammunition boxes and the loading machine; and the third, fourth, and fifth each with 6 ammunition boxes and 2 water boxes. The additional spare parts, accessories, tools, etc., to be distributed among the last three.

During the year 40 Gatling guns, model of 1903, were procured. These guns were built for the model of 1903 cartridge.

Cavalry sabers.—As the supply of light cavalry sabers on hand at the close of the civil war has been practically exhausted, an order for the manufacture of 20,000 has been given. The bands on the scabbard will be located nearer the mouthpiece, so as to bring the lower band above the center of gravity of the scabbard and sword. As the black nickeling prescribed for scabbards by General Orders, No. 81, of 1902 frequently peeled off in service, all scabbards will hereafter be browned.

Miscellaneous.—Five thousand machetes and scabbards were purchased during the year for the use of troops serving in those parts of the Philippines where the dense undergrowth renders them necessary. Three thousand knives and scabbards of special design for issue to the Hospital Corps are being made. As scabbards for officers' sabers made of German silver under General Orders, No. 81, of 1902, proved too soft for service conditions, they are now being made of steel and then heavily nickel plated. The guard will, for the same reason, be made of bronze, heavily nickel plated. The black nickel scabbard for officers has been abolished.

SMALL-ARMS AMMUNITION.

The ball cartridge, model of 1903, has been perfected and manufactured in quanity during the year.

Guard cartridge.—The multi-ball cartridge, caliber .30, has been replaced by a "Guard" cartridge having a single lead ball, weighing 156 grains. A sufficient powder charge is used in this cartridge to give the bullet a muzzle velocity of 1,150 feet per second.

Gallery practice cartridge, caliber .30—An elongated lead bullet, weighing 107 grains, provided with two cannelures for holding lubricant, has been substituted for the round ball. With this form of bullet much greater accuracy is obtained.

Additional safeguards have been adopted to prevent the accidental packing of ball with blank cartridges. Hereafter each pasteboard box of 20 blank cartridges, when sealed, will be weighed, the difference in weight between a service and a paper bullet being sufficient to enable the presence of one of the former bullets to be detected. In addition, the length of the blank cartridge, model of 1903, has been reduced one-tenth inch, and the machine for inserting cartridges in the clips adjusted so as to prevent the insertion of a ball cartridge in a clip loaded with blanks.

Experiments have been made with a view of obtaining a suitable bullet for small arms and machine guns that will penetrate the hardened protective shields with which modern field artillery are provided. No success in this line has yet been attained.

Bandoleer.—The experiments referred to in my last report, made to develop a cheap cloth bandoleer having six pockets, each containing

10 cartridges, have been completed, and hereafter all caliber .30 ball cartridges, models of 1898 and 1903, will be packed and issued in bandoleers instead of pasteboard boxes.

The wooden packing boxes for ball catridges have been sufficiently enlarged to hold 20 bandoleers, or 1,200 cartridges. The boxes containing model of 1898 cartridges weigh 92 pounds, and the model of 1903, 99 pounds. This new box can be packed on an aparejo with facility and it enables one mule to carry 40 per cent more cartridges without undue burden.

A distinctive colored label on the pasteboard boxes has been adopted for each kind of cartridge.

SMALL-ARMS TARGET PRACTICE.

The Firing Regulations for Small Arms, dated January 1, 1904, prescribed a number of new targets which were made and issued in time for this year's target practice. As the adoption of a primer composition containing no fulminate of mercury, and of improved methods of manufacturing cartridge cases has overcome the splitting of the latter when fired a few times, the practicability of reestablishing the system of reloading ammunition by troops is under investigation in order that the expense incident to the increased allowance per man for target practice may be reduced as much as possible. The privilege of exchanging empty cases for new ammunition has been extended to the militia of the several States and Territories. A number of targets have been made in accordance with a design submitted by Maj. C. H. Murray, Fourth Cavalry, and issued for trial. The reports so far received indicate that it is superior to existing designs.

EQUIPMENTS.

The adoption of the new rifle for all arms of the service rendered necessary a new design of gun sling and of scabbard, both of which are being manufactured. The gun sling was shortened so as to provide only two thicknesses of leather except near the butt swivel. The manufacture of the new cartridge belt described in my last report has been continued during the year and the limited experience so far had with it has been satisfactory. A new woven strap has been adopted for attaching the canteen to the belt, which will replace the leather canteen strap heretofore issued to the cavalry. Pouches for the first-aid packet are being made in quantity in accordance with the design of Lieut. Col. John Van R. Hoff, Medical Department.

Russet leather.—Equipments made of the stuffed russet leather prescribed by General Orders, No. 81, 1902, soiled the soldiers' clothing to such an extent that it was found necessary to adopt a leather containing even less oil than that referred to in my last report. The greater part of the leather equipments so far made during the present calendar year have been made of this new leather. It is believed that the khaki and olive-drab uniforms prescribed by the same order show grease stains much more plainly than the blue. A process was devised at Rock Island Arsenal by which nearly all the oil in the first leather can be removed, and orders have been given to apply it to a sufficient number of the different leather equipments, which, with those made of the new leather, will enable all of the older in the service to be replaced. The equipments thus replaced will be cleaned and stored as part of the reserve supply, since the oily leather keeps much better in storage. The manufacture for sales to officers of sword belts and dispatch cases of pigskin has been approved by the Chief of Staff.

With a view to improving the equipment, General Orders, No. 81, 1902, directed the manufacture of certain articles for trial. One thousand each of cups and meat cans were made of aluminum and issued to troops in the Philippine Islands. The reports were in general favorable in regard to the meat cans, but much complaint was made of the retention of heat by the cups and particularly by their handles, due to the high conductivity of aluminum. Tests were therefore made at Rock Island Arsenal to ascertain the extent to which this defect could be mitigated. As the use of a tinned steel handle with fiber washers between the handle and the aluminum body was found to remedy this defect, 5,000 cups are being made for further trial. This latter cup weighs 4¾ ounces and the present design 7½ ounces. The new meat can weighs 9¼ ounces and the present design 15¼ ounces. As no commercial method is known by which aluminum can be soldered, canteens of the present shape could not be made for trial.

One thousand each of experimental watering bridles, combination halter bridles, Pelham bits, and picket pins of two different designs have also been manufactured and issued to the service for trial. As soon as reports have been received from all the organizations by which they were tested they will be submitted to the Chief of Staff for his action.

SERVICE GUNS AND MORTARS.

These have been maintained in a satisfactory state of efficiency. The new firing mechanisms referred to in my last annual report are now being assembled, and this work will continue in the different armament districts as rapidly as possible. Efforts to improve the rapidity of fire of seacoast and other guns have not been relaxed. The direction of such efforts during the year has principally been confined to mechanical rammers, automatic breech openers, and desirable changes in details of existing mechanism.

An experimental mechanical rammer was designed and tested with a 12-inch B. L. rifle on a 12-inch disappearing carriage, L. F., model of 1901. The object of this device is to decrease the time and labor required to seat the projectile and powder charge in the chamber of the gun. It consists of a car, traveling on a circular track on the loading platform of the emplacement, and carrying separate loading trays and rammers for the projectile and powder charge. The force required for seating the projectile in the bore is obtained from springs compressed by hand power between shots. The powder is seated by a rammer actuated by hand power only. The results of the tests of the device showed (*a*) the projectile was discharged into the gun at such high velocity that hardened-steel projectiles would injure the rifling and parts of the bore about the entrance to the projectile seat; (*b*) with the present form of powder grain and quantity required for full charge, that all sections of the charge can not be inserted simultaneously. The device will be altered so as to insert and seat the projectile at a lower velocity, and subjected to further tests. The difficulty of inserting the powder charge in one operation would, it is believed, be overcome by the substitution of rods for the present grains of powder.

An experimental mechanical breech opening and closing device has also been designed and made. It is now being tested on a 12 inch B. L. rifle mounted on a disappearing carriage.

EXPERIMENTAL GUNS.

10-inch Brown segmental-tube wire gun.—This gun was constructed and is being tested under allotments made by the Board of Ordnance and Fortification. It was completed some time since and the test under a programme of firing 100 rounds commenced. Since November, 1903, when 15 rounds had been fired, the test has been discontinued, owing to the disabling of the locking device of the breech mechanism in firings about that date. Some changes in this device will be required, and this office is informed that steps are to be taken by the company with a view to the removal of the gun to the Scott Foundry, Reading, Pa., for this purpose.

6-inch Brown segmental-tube wire gun.—The cost of the manufacture and test of this gun will be defrayed from allotments made by the Board of Ordnance and Fortification. This gun and mount was delivered at the Sandy Hook Proving Ground for test October 4, 1904.

6-inch wire-wound gun, Ordnance Department design.—This gun is now under construction at Watervliet Arsenal, the cost of its manufacture and test being defrayed by allotments from the Board of Ordnance and Fortification. The manufacture is proceeding satisfactorily, and it is expected to be delivered at the proving ground for test about November 15, 1904.

Semiautomatic 15-pounder R. F. gun and mount.—This gun will be manufactured and tested under allotments from the Board of Ordnance and Fortification. The gun is of higher power than guns of the same caliber which have been heretofore manufactured, and the semiautomatic breech and firing mechanism follow designs submitted by the United States Ordnance Company. This gun and mount should be completed and ready for test during the fiscal year 1905.

Semiautomatic 6-pounder guns.—Allotments were made by the Board of Ordnance and Fortification during the present fiscal year for the purchase of several types of these guns with power to give to the projectile a muzzle velocity of 3,000 feet per second. Proposals have been invited and contracts made for the construction of four guns and mounts complete, the chambers of the guns being designed to permit the use of ammunition prescribed by this Department. These guns should be completed and delivered at the Sandy Hook Proving Ground in the early part of 1905, and their test will be undertaken immediately thereafter.

MOUNTAIN ARTILLERY.

The completion of the remaining carriages which are being made at the Watertown Arsenal for the 75-millimeter mountain guns and of the pack saddles under manufacture at the Rock Island Arsenal will provide 120 mountain guns, carriages, and sets of pack outfits. Although these carriages are of recent design, the practicability will be investigated of altering them so as to increase the length of recoil of the gun on the carriage, to make the latter more stable during firing, thereby increasing its rate of fire. A sufficient number of pack saddles are being made to provide each gun with 13 saddles, enabling 100 rounds of ammunition to be carried per gun. Each battery will be provided with two additional saddles for saddlers' and farriers' tools.

MOUNTAIN GUNS AS FIELD MORTARS.

Experience in the Philippine Islands indicates the desirability of firing mountain guns at higher angles of elevation than originally contemplated by existing designs. In order that proper plans may be made for the use of these guns in this manner, experiments are now in progress to determine the number of powder charges required, with proper overlap of zones of fire, to cover the field within the range of the guns under conditions considered to be necessary for the proper realization of the effect desired. In view of the lack of adaptability of fixed ammunition to the possible requirements of such service, consideration will be given to the subject of separate loading for this purpose, in connection with arrangements required for packing it. It is recognized that to realize efficient service from such material a number of changes are required, and the tests in progress have for their purpose the determination of these changes in connection with the acquirement of additional knowledge in regard to the effectiveness of these guns in high-angle firing.

FIELD ARTILLERY.

The manufacture of the 3-inch field artillery matériel has progressed satisfactorily during the year. The difficulty referred to in my last report of obtaining the superior quality of materials required in its construction has been overcome with the exception of the counter-recoil springs and panorama sights. All of the matériel except these two articles is being procured in this country. Repeated efforts have been made to interest American manufacturers in the making of the two excepted articles and, it is believed, with success. Appropriations have so far been made for 26 complete 3-inch field batteries for the Regular Army and 26 batteries for the Militia, all of which are now under manufacture, except 6 guns, carriages, and limbers, which have been completed and issued. The remainder should be finished by October 1, 1906. The pilot 3-inch carriage was completed and proof-fired at Rock Island Arsenal last December, and was then sent to the Sandy Hook Proving Ground for further test. There have been fired from it 787 rounds. As the margin of stability of the carriage for horizontal fire was found to be greater than necessary, the length of recoil of the gun on the carriage was reduced from 48 to 45 inches. The action of the carriage with the 45 inches of recoil was highly satisfactory.

The design of the sights for this carriage was completed after much study, and sights are now being made at Frankford Arsenal for all carriages under manufacture. The sighting apparatus differs materially in design and operation from that previously used in our service; the principal difference consists in the provisions made for indirect laying of the gun and for setting it in elevation from either side of the piece. This latter provision enables the piece to be kept constantly on the target, and results in an increased rate of fire. On the left side of the carriage there are an open front sight, with cross wires, and a rear sight, the shank of which carries a peep and a panorama sight. The latter sight has a 1-inch objective, a field of view of about 10°, a magnifying power of 4 diameters, and forms the image erect. The axis of the objective is 5.6 inches above that of the eyepiece, and by means of worm gearing can be rotated through any angle about the vertical axis of the telescope. A glass reticule is provided with horizontal and vertical cross lines, and two additional horizontal lines, 3 and 6 millièmes, respectively, above the horizontal line. The rotating part carries a disk graduated to 64 points, each point being 100 millièmes. The rotation of the eyepiece is effected by means of a worm provided with a micrometer giving a least reading of 1 millième or one one-thousandth of the range. The shank can be swung laterally to correct for differences in level of the wheels; it has an elevation scale graduated in yards, and a deflection scale graduated in points.

The range quadrant on the right side of the piece has adjustments for correcting for differences in level of the wheels and for the angle of site. It is graduated in yards. A battery commander's telescope is now undergoing trial; its telescope is similar to that of the panorama sight and has vertical and horizontal scales graduated to the same unit as the panorama sight.

The different breech mechanisms for field guns referred to in my last annual report have been tested for the purpose of ascertaining their relative merits and to develop desirable features for adoption in future manufacture. The report of the Ordnance Board on this subject is contained in Appendix VI of this report. The results of these tests indicated that the mechanism of the present 3-inch guns, model of 1902, is of a safe type and fitted to render efficient service. The opinion was expressed, however, that it could with advantage be replaced by a simpler type involving less care in maintenance and less expense in manufacture. Of the designs tested, the Tasker, submitted by the United States Ordnance Company, was found to possess marked advantages over the others, and arrangements are now being made with a view to the utilization of this design in field guns to be manufactured this year.

The preparation of general designs of a 3.8-inch field gun and carriage and of a 2.38-inch field gun and carriage was assigned to the student officers of the Sandy Hook Proving Ground as part of their instruction, and was creditably completed by them. This design of the 3.8-inch field carriage was sent to Rock Island Arsenal, where detailed working drawings were prepared by Capt. George W. Burr, Ordnance Department, which are now undergoing final examination. The 2.38-inch gun and carriage will also be used around seacoast forts, as recommended by the Board of Ordnance and Fortification, December 3, 1903.

Upon its completion the automobile forge and battery wagon referred to in my last annual report was successfully run from Jersey City, its place of manufacture, to this city under adverse conditions of roads, and was further tested on the various roads in this vicinity. During the summer it was issued to the battalion of field artillery at Fort Myer, Va., for further test during practice marches and the Manassas maneuvers. The wagon when fully equipped for the field weighed about 12,000 pounds, which was too great for the bridges and culverts found on the average country road. Much valuable information and data were obtained from the building and operation of this wagon, which are being utilized in a new design under preparation in this office. The new wagon will carry complete machinist's, carpenter's, saddler's, and farrier's tools, and a limited quantity of supplies, but no spare parts, etc., for the battery. This will enable the weight of the loaded vehicle to be reduced to less than 8,000 pounds. The motive power will be supplied by four cycle gasoline engines, as in the earlier model.

As rapidly as the present 3.2-inch is replaced in service by the 3-inch field matériel it is proposed to thoroughly overhaul and repair the former, preparatory to its storage as part of the reserve supply, until a sufficient supply of the later design is obtained.

EXPERIMENTAL FIELD MATÉRIEL.

Although a satisfactory system of field artillery has been adopted, the policy of the Department to continue tests of promising designs has been continued.

Small-caliber field gun.—Claims having been made that a field gun of about 2 inches in caliber, mounted upon a long recoil carriage and firing high explosive shell weighing about 5 pounds, would in a given interval be more effective than a 3-inch field gun firing shrapnel, tests were made during the year for the purpose of securing information and arriving at an opinion in regard to the relative value and serviceability of such material. These tests have not sustained the claims above mentioned. On the contrary, the rapidity of aimed fire from these two guns not being very different, the relative value of their fire is to be regarded as more nearly proportioned to the weights of their respective projectiles, especially when it is considered that the 3-inch gun will fire both a 15-pound high explosive shell and 15-pound shrapnel. The usefulness of the small-caliber explosive shell is apparently restricted to destructive effect by direct projectile hits upon exposed matériel, such as field guns, caissons, houses, etc., since its explosive charge is not sufficiently powerful to be of much value in breeching effect.

The pattern of such small caliber shell exploded in flight is similar to that of the 15-pound shrapnel—i. e., the fragments are projected forward in a similar cone of dispersion. The shell was, however, of slight value in its effects against troops in the open, since the action of its percussion fuse was such that the burst occurred frequently on impact with the ground or after ricochet on a rise of a few feet only. Its value in this respect would probably have been improved by having a longer delay action in the fuse. The form of the cone of dispersion due to the small bursting charge was such that the shell could not be used for searching effect on troops in ditches or behind parapet. Capacity to accomplish this purpose is generally regarded as the chief reason for employing high explosive shell with field guns. It may be remarked that the plans of this Department contemplate the use for field purposes of a lighter gun than the 3-inch gun now under manufacture, and it is proposed to make the caliber of this gun 2.38 inches, the projectile for which will weigh 7½ pounds, this being considered the smallest caliber which can employ an efficient shrapnel.

The latest designs of 3-inch field guns and carriages of the Bethlehem and Ehrhardt types were also tested during the year.

SIEGE ARTILLERY.

A 4.7-inch siege gun and long recoil carriage has been designed and the carriage partly completed during the year. When finished, they will be thoroughly tested prior to their manufacture in quantity. The gun fires a 60-pound projectile with a muzzle velocity of 1,700 feet per second, and has a recoil of 66 inches on the carriage. A 6-inch siege howitzer and carriage is being designed in this Office, and when completed a pilot carriage and howitzer will be built for test. In order that full advantage may be had of the experience gained at arsenals in the manufacture of carriages, and to give different officers the professional benefit derived from designing ordnance material, the designing of a 6-inch howitzer carriage was assigned to and completed by Capt. Lawson M. Fuller, Ordnance Department, while on duty at Rock Island Arsenal, and that of a 4.7-inch howitzer carriage to Capt. Colden L'H. Ruggles, Ordnance Department, on duty at Watertown Arsenal. The first design has been completed and is a creditable production; the second is not completed.

A board of artillery officers having recommended that the wheels of siege carriages and limbers be provided with tires 5 instead of 4 inches in width, tests were made at Rock Island Arsenal with a 7-inch siege howitzer carriage and limber with wheels having tires 3, 4, 5, and 6 inches in width on seven different kinds of roads. A description of the roads, material, and method of making the tests, and the results obtained, forms Appendix III. The results of the tests show that although the wider tires are less destructive to roads, the 4-inch tire requires less tractive force and is better suited for siege artillery than 5 and 6 inch tires.

SEACOAST CARRIAGES.

The manufacture of seacoast carriages during the year has progressed to the extent permitted by appropriations for the purpose. In addition to the carriages being manufactured at arsenals, contracts exist with the following private manufacturers, namely: 15-pounder guns and carriages and 4½-inch shields, with the Bethlehem Steel Company; 6-inch barbette carriages, model of 1900, with the Builders Iron Foundry; 5-inch barbette carriages, model of 1903, and 6-inch disappearing carriages, L. F., model of 1903, with the Morgan Engineering Company; 6-inch disappearing carriages, L. F., model of 1903, with the Mansfield Engineering Company, the Detrick and Harvey Machine Company, and the Wellman-Seaver-Morgan Company.

The progress made in the manufacture of the 15-pounder guns and mounts has not been satisfactory. A satisfactory design of telescopic sight has only recently been submitted and approved.

After much delay a contract was finally entered into for the 4½-inch shields required for the 6-inch barbette carriages under manufacture. In view of the experience had in the manufacture of this lot, no difficulty is anticipated in procuring shields for the 5-inch barbette carriages.

The 6-inch disappearing carriage, L. F., model of 1903, is essentially a rapid-fire mount. The time required for the gun to rise into battery has been reduced to about three seconds. In the shop tests of several carriages this operation required only two and three-fifths seconds. A sighting platform and 3-inch objective telescopic sight are provided on each side of the carriage. On the left platform are handwheels for traversing and for elevating, and on the right a handwheel for traversing only. This enables each of the operations to be performed by a separate gunner when direct fire is used. Springs, which the upper ends of the gun levers compress during the last part of their rotation in recoil, accelerate the beginning of the return of the gun into battery.

10-INCH EMERY DISAPPEARING CARRIAGE.

In accordance with the provisions of the fortifications act approved April 21, 1904, it was directed on June 9, 1904, that the contracts made with A. H. Emery for one 12-inch depression carriage and loading apparatus be closed, and that a new contract be entered into with him for one 10-inch disappearing carriage to be furnished in place of the 12-inch, together with its foundations, erection, and preliminary tests by him, ready for proof tests for the price of $84,383.02. The contract was made on June 13, 1904, and its construction was immediately begun by Mr. Emery.

TELESCOPIC SIGHTS.

Orders have been given during the year for 271 of the 3-inch objective telescopic sights described in my last report. Several minor changes in their design have been made. The design of a similar telescopic sight has been undertaken for application to all rapid-fire mounts in service.

NEW DESIGNS AND PROPOSED ALTERATIONS IN SEACOAST CARRIAGES.

As much time is consumed in applying a quadrant to a mortar each time it is laid in elevation, several different designs of fixed quadrants and elevating devices have been made and tested. The design submitted by Capt. E. P. O'Hern, Ordnance Department, was found to be most satisfactory, and a number are being made for practical test during next year's army and navy maneuvers. The design of the safety firing switch for mortar carriages has been completed and the switches ordered applied to all carriages in service. This switch positively breaks the firing circuit until the mortar is elevated to 45°, the lowest elevation at which mortar fire is had.

All of the 12-inch disappearing carriages, L. F., model of 1897, will be provided during the coming year with complete electric traversing, retracting, elevating, and depressing equipments; 3-inch objective telescopic sights, sighting platforms, counterbalance devices, etc., which will make them in all material respects the same as the 12-inch disappearing carriages, L. F., model of 1901. All 12-inch disappearing carriages, L. F., model of 1896, in service are being equipped with electric retracting equipment. The retracting gears of the 8-inch and 10-inch disappearing carriages, L. F., model of 1894, are being redesigned and will be provided with wire retraction ropes. The only means provided on the 15-pounder barbette carriages, procured from the Driggs-Seabury Company, for moving the gun in azimuth, was the shoulder bar, which experience shows is not satisfactory. A system of gearing for this purpose has been designed and will be applied to all carriages in service when funds permit. A multiple scale for range drums and pointer has been designed and a number will be issued for trial. The design allows the effect upon the range of all variations in the muzzle velocity from the standard to be corrected for by data obtained from a trial shot.

The investigations for verifying the accuracy of the formulæ heretofore used in the calculation of the throttling openings of the hydraulic recoil system of gun carriages, referred to in my last report, have been continued. A formula has been experimentally determined which, with those formerly used, allows for the contraction of the liquid vein, and has been practically tried in different carriages with excellent results. It is found that the flow of oil through the orifice varies materially with the form of piston used. These investigations will be continued.

MAINTENANCE AND CARE OF THE ARMAMENT OF FORTIFICATIONS.

The system of dividing the seacoast and field armament for maintenance and improvement into districts continues to operate most satisfactorily and to save much time and unnecessary correspondence. It will be extended to include all the principal material furnished by this Department, such as range-finding instruments, powder, projectiles, etc.

The results obtained from the installation of the small machine shops at the principal seacoast fortifications have demonstrated the economy of that method of making repairs and minor alterations.

DEFENSE OF INSULAR POSSESSIONS.

Appropriations made by Congress at its last session provide for the commencement of the fortifications of the insular possessions. The needs of the Ordnance Department on account of this work are pointed out under the heading of Manila Ordnance Depot.

RANGE-FINDING INSTRUMENTS.

Contracts have been made during the year for 159 Swasey depression position finders, type A, of which 40 have been completed. One hundred and fifteen Pratt's ballistic boards and 200 Whistler's plotting boards are being manufactured at Frankford Arsenal. At the suggestion of Major Whistler and Captain Hearn, Artillery Corps, a gun arm has been added and the azimuth circle changed, which makes the Whistler plotting board universal in its application and reduces the number required by one-half. A number of minor changes recommended by the artillery board have also been embodied in these boards. Standard designs of predicting scales, set-forward computers, and deflection correction devices have not yet been adopted.

EXPERIMENTS TO DETERMINE THE DANGER OF IGNITION OF FIXED AMMUNITION FOR FIELD GUNS.

These experiments were made with .30-caliber bullets and 1-pounder projectiles, the former being fired to strike cartridge cases of fixed ammunition for field guns with varying velocities corresponding to remaining velocities in flight. The charges in the fixed ammunition were in no case detonated. To ignite the charges, a velocity of 2,000 feet per second in the .30-caliber projectiles was required. The 1-pounder projectiles were fired with a charge to give velocities of 2,000 feet per seconds, and while the powder in the cartridge cases was not in all cases ignited by the impact, this occurred often enough to show that it will be the probable result. After firing at single cartridges suspended in the air the 1-pounder projectiles were fired at a box containing ten cartridges. In one case only one charge was ignited, and it burned without setting fire either to the box or to the remaining cartridges, and in another case three cartridges were ignited and the resulting fire set fire to the box. During the burning of the box one other charge exploded; the remaining six were recovered without apparent injury. It is inferred from these results that there will be no danger of detonations from field cartridges by the impact of field artillery or small-arms projectiles.

STREAKED FORGINGS.

The tests of streaked metal in gun forgings have been continued during the year. Streaks are, as a rule, of little depth, and attempts to locate tangential test specimens in such a way that streaks could be subjected to test by tensile forces normal to their surfaces have been more or less unsatisfactory. By taking smooth cuts on the faces of rings, streaks are revealed in cross section as lines of varying length up to one-half inch or more, and, being of circumferential direction, radial specimens traverse the streaks in a favorable manner for test. The streaks thus appearing on the planed faces of the rings were numerous, not infrequently reaching five per square inch; but attempts to photograph them were unsuccessful. One piece of metal was planed to a thickness of 0.2 of an inch; a prominent streak was revealed and three radial specimens were taken across it. Several specimens fractured along the line of this streak, with a reduced elastic limit and tensile strength and very little elongation and contraction of area. It is true that the contraction and elongation of specimens taken at right angles to the direction in which the metal is principally drawn by forging are not expected to be so great as these characteristics in specimens taken with axes parallel to that direction; but the elongation and contraction of metal sound in the ingot should not be so reduced or affected in any direction by forging as to vary in metal forged in the same way by the same manufacturers from practically nothing to almost as much as shown by the best specimens taken with axes parallel to the direction in which the metal was drawn, nor should sound metal be so affected by proper forging as to lower its ductility in any direction far below that which should be displayed by ordinary steel castings. From a number of tests made upon metal received from abroad the results of the tests of the radial specimens were nearly equal to those of the tangential specimens. These records, while not numerous, serve to indicate that a defective radial specimen is not necessarily a natural consequence of forging steel.

It can not be assumed that all streaks will be disposed with their surfaces concentric with the cross section of the forging, i. e., parallel to the principal stresses which will act on a hoop or tube when assembled in a gun. It is quite probable that some of the numerous streaks will be so deflected that their surfaces will take an inclination spirally toward the axis, bringing them across the direction of the principal stresses and thereby menacing the strength of the forging.

The tensile tests now prescribed by the specifications show the physical qualities of the metal resulting from its carbon content and heat treatment, but only by chance do they reveal the presence of a defect. Tests having for their special object a revelation of defects impairing the strength and ductility of forgings as a whole below what has been shown by the tensile test specimens are therefore necessary. It is possible that a mandrel test may be the means for determining the presence of such defects, and this test is under consideration. It is considered to be less expensive and more comprehensive than a requirement that as many small tensile specimens be tested as may be taken from the end of a forging.

SMOKELESS POWDER.

This Department has continued its investigation of smokeless powders with a view to improving their qualities to enable them to be fired under pressures of from 40,000 to 45,000 pounds per square inch for the purpose of utilizing the strength of our service guns. It has been noted that some powders when fired at high pressures develop critical points in their pressure curves, or points at which the rate of evolution of gases suddenly increases for an increase of charge, resulting in excessive pressures, often exceeding the elastic strength of the guns. Early examination of some such powders indicated them to be normal, except that the material of the grains appeared to be more brittle than those of other lots. When struck by hammer on an anvil or when compressed longitudinally in a vise pieces would break away from the grain with more or less violence, while grains from other lots of powder without critical points would be compressed to flat disks without breaking into separate and detached pieces. This quality of brittleness is considered to be a source of danger, and the experiments in regard to it have resulted in the introduction into the specifications for smokeless powders of a test to determine the toughness of the colloid. This test is as follows: Take 10 powder grains representing a lot of powder to be examined and cut off both ends of each grain at right angles to the length of the grain until the length equals the diameter=1. Compress these slowly between parallel surfaces until the first crack appears. The decrease in length necessary to crack the grain is calculated as a percentage of the original length, and the average must not show less than 45 per cent. A very good powder should show over 50 per cent.

When attention was first invited to the effect of brittleness it was suggested as being important that the relation between brittleness and percentage of volatiles be determined, and three samples of powders having percentages of volatiles of 4.33, 3.73, and 3.33, respectively, were selected for test. When fired no critical points were obtained in any of the pressure curves. One of the samples was placed in the heating chamber and the temperature regulated at 120°, which was subsequently raised to 150° and then to 180° F. The heating was continued at intervals for about six months. The test indicated that under continued drying at high temperatures a maximum of quickness is reached after which, for some reason, the powder becomes either slower or weaker. An important deduction is that as long as powders retain their normal percentages of volatiles from which they are with difficulty deprived, they should not give dangerous pressures in firings with service charges, and the toughness of the powders was found not to be materially affected by considerable variations in the normal percentages of solvents. The Department has now under consideration a possible change in the form of the grain to increase the progressiveness of the powder, and the necessary investigations may even lead to a change in the composition.

The reserve supply of powder issued to posts is stored in hermetically sealed galvanized cases. These cases are effective, can be repeatedly used, and have sufficient strength to permit of their being piled on their sides in tiers as high as the head room of magazines will permit. Some of the early forms of cases were sealed by balata washers, which were found to be unsatisfactory. Means have been found by which these can be converted at a very slight expense into those of later model in which the sealing is done by a soldering strip, and the changes are being made as rapidly as possible.

ETHER-AIR MIXTURE.

The presence of the odor of ether in magazines containing smokeless powder has resulted in inquiries as to the dangerous nature of an ether-air mixture. This odor results from the escape of ether from storage cases which are not perfectly sealed, owing to the deterioration of the balata washers which were formerly used for this purpose. It has been found that a mixture of ether vapor and air becomes explosive when the proportion is 1.7 cubic feet of ether vapor to 100 cubic feet of air, leading to the conclusion that ether vapor is never present in our powder magazines in sufficient quantity to form an explosive mixture with air. When the changes in the cases having balata washers have been completed, the odor which has heretofore been present will probably disappear.

FUZES.

Experiments during the year have been principally with centrifugal fuzes. Several tests have been made of experimental lots of Frankford Arsenal combination fuzes. The difficulty in igniting the time train, which was encountered in the first model, has been entirely removed. There is, however, a tendency to burn with occasional irregularity when set above ten seconds. Difficulties in controlling and regulating the burning of the powder time train for combination fuzes have led inventors to attempt to devise a mechanically operated time fuze, but the results so far, although interesting, have not been successful. Two fuzes of this class have been tested during the year, the test of one being still in progress. This class of fuze is intended to be operated by the rotation of the projectile during flight.

ARTILLERY TARGET PRACTICE.

Recent orders prescribing the annual allowance of ammunition for artillery practice require a reduced amount for guns of larger caliber and an increased amount for subcaliber tubes, for the purpose of giving larger experience in fire-command practice. The present scheme of practice with subcaliber tubes contemplates the manning of two guns in every battery and four mortars in every mortar battery at any one post in an artillery district at the same time. Since it is planned to transfer tubes and fixtures from one post to another in the same artillery district, it is expected that this method will result in a reduction in the originally estimated cost of providing them. The service of subcaliber tubes with guns on disappearing carriages requires the use of platforms on which cannoneers can stand to load the piece. Such platforms have been designed and are now undergoing test. The design contemplates the permanent attachment of certain parts to the gun and carriage, to which the platform can be hooked. A few additional fixtures will be required, and arrangements for their purchase are now being made. Steps have been taken to make cast-iron projectiles for target practice similar in form and weight to the steel armor-piercing projectiles, and a sufficient number of the former will be on hand to permit their use after July 1, 1905.

Point-fused, large-capacity shell for 1-pounder subcaliber tubes have been tested satisfactorily, and a large number are now under manufacture.

Similar shell for 75-millimeter tubes have failed to meet the expectations of this Department, owing to the failure of the shell to burst sufficiently near the surface of the water at high angles of elevation to permit the smoke of the bursting charge to be observed. When these shell have been fired for impact through board screens or on the beach or on water, within the ricochet angle, the results have been satisfactory. When the angle of fall has been beyond the ricochet angle, however, all fuses have failed to work, or they have exploded too far below the surface of the water to be of any use in promoting visibility. For the present, therefore, the 75-millimeter subcaliber shell will be issued sand loaded, without fuse. Experience indicates that the point of striking the water under these conditions can be observed at usual ranges if the approximate point of striking is known in advance. In the meantime attempts will be made to use a base fuse in these shell with less delay action, to make the shell burst before they are too deeply submerged.

ARTILLERY TARGETS.

Improvements have been made during the year in the heavy-gun and rapid-fire targets for artillery practice. The latter is intended to be hit and is sometimes called "material target." The former marks off a distance of 150 feet, the length of the superstructure of a 360-foot battle ship, and is constructed to assist in locating shots and not to be hit. The trials indicate that the heavy-gun targets can be towed in tandem 150 feet apart at any practicable speed and in any sea that will not carry away the canvas, and that the flag line joining the mastheads can be kept sufficiently taut without causing the rear target to show a tendency to dive. If anchored, either target will support at least 300 feet of anchor rope. The rapid-fire target consists of a flat area of cloth 20 feet long and 5 feet high, about 2 feet in the clear above the water. The cloth is painted red and the framework can be quickly repaired when any portion of it is shot away. Trials have indicated that this target has a satisfactory buoyancy when towed at all practicable speeds, even in rough water. If the necessary precautions are taken in moving the targets to and from the water, in adjusting the ropes for successful towing, and in preserving the targets during storage on land, it is thought that they will prove economical forms for service.

DUMMY PROJECTILES.

A change in the form of the dummy projectiles has been found necessary to protect the rifling of the guns near the powder chamber. The cast-iron body of the original projectiles not only struck the rifling at the bourrelet, but also on the cylindrical part of the body. The new pattern is provided with a bronze band at the bourrelet and has a reduced diameter of body to prevent contact with the rifling at the slope.

SMALL C.

The determination of data for range tables for service guns has involved a large amount of firing at numerous ranges, owing to the fact that the coefficient c is found not to be constant. This coefficient was introduced into ballistic equations for the purpose of making them apply to projectiles of varying form. For a standard projectile this coefficient has been taken as unity, and for a projectile offering greater or less resistance in flight it would be greater or less than unity. Firings so far have not succeeded in establishing the law of variation of the value of this coefficient. In some cases it has its least value at the shortest ranges, increasing to the maximum range. In other cases the value decreases as the range increases, while occasionally a maximum has been reached a little beyond mid range. These variations of value require a sufficient number of targets to establish a curve of values of this coefficient as a function of the range, it being desirable to incorporate the varying values of this coefficient in range tables, instead of using a constant value, as has been the practice heretofore.

RANGE FIRING WITH MORTARS.

The present scheme of range firing from seacoast mortars contemplates the sweeping of the field of fire from a range of 3,000 yards to the maximum range of the mortars. The field between these limits is divided into ten zones, requiring ten different powder charges. At present the maximum range obtainable is 10,800 yards, due to the inability to fire the mortars with sufficiently large charges to give the requisite muzzle velocity for longer ranges, owing to weaknesses which have developed in certain parts of the mount. To remedy this and also increase the angle of elevation to 70°, parts of the mount have been redesigned. The principal changes consist in placing on each side of the mortar opening in the racer a girder on which the recoil cylinders are trunnioned, and in replacing the five throttling holes with continuous throttling grooves cut in the walls of the recoil cylinders. When these alterations have been made it will be possible to sweep the field of fire from ranges of about 2,000 to 11,400 yards, and the number of zones required can be reduced to six, or possibly to five. This is particularly advantageous on account of the reduction in the large number of powder charges required by the existing scheme. Under the proposed plan 1,000-pound projectiles will be used with five different charges of powder from the shortest to a maximum range, the angles of elevation varying between 45° and 70°, except that with full charges the highest angle of elevation will be limited to 65°. On account of this limitation it may be found possible to omit the girders, which it has been proposed to add to the carriages. Eight-hundred-pound projectiles will be used for the outer zone only, to extend the ranges requiring full charges and velocities of 1,325 feet per second, with elevations between 45° and 65°.

Attention is invited to the report of the Ordnance Board in regard to this firing, which is made Appendix V of this report. Recent firings with these mortars indicate very clearly that the drift of mortar shell is to the left for angles of elevation between 60° and 70°. The point of crossing from left to right of the plane of fire seems to vary somewhat with different projectiles, but all of the curves cross before the elevation drops much below 60°. The drift to the right seems to be a maximum for an elevation of about 55° and to then decrease, showing a marked tendency to recross the plane of fire for an angle less than 45°. In order to investigate this tendency more fully and at less expense than that which would result from firings from 12-inch mortars, a series of firings was made from the 75-millimeter subcaliber tube in the 12-inch mortar to include all angles of elevation between 5° and 70°. These latter firings indicate that for the atmospheric conditions existing at the time of the test the 75-millimeter projectiles did not at high angles of elevation show a drift to the left of the plane of fire. A tendency of the projectiles to go to the left was, however, apparent.

DEFLECTION OF 12-INCH TORPEDO SHELL.

In order to determine whether 12-inch torpedo shell on striking water are deflected toward the surface at any angle of fall, a series of experiments have been inaugurated to embrace the action of projectiles on water impact from the .30-caliber bullet to the largest projectile the trajectory of which under water can be recorded. The firings from a .30-caliber rifle were made from a rest, the inclination to the surface of the water being varied; for each inclination a charge was used to give initial velocities to projectiles of 500, 700, 900, and 1,100 feet per second. Thin vertical screens of suitable material were placed near each other and under the water, and the holes made by the bullets in passing through enabled the trajectory to be plotted. The results indicate that the small-arms bullet is first deflected downward toward the normal and then shows a decided tendency to move away from it. In several cases the trajectory, due to this movement, passed the prolongation of the axis of the piece. The energy of the bullet is so rapidly dissipated it is difficult to say how much this movement toward the surface of the water might amount to in a projectile weighing 1,000 pounds. It was observed, however, that the tendency of the bullet to rise to the surface of the water increases as the angle between the line of fire and the surface of the water decreases. It is apparent that for some angles less than 15° the bullet will enter and emerge after traveling some distance under the water. For an angle of fall of 15° the .30-caliber bullet, with a striking velocity of 500 feet per second, travels horizontally about 100 calibers after penetrating to a depth of about 23 calibers. These figures are not materially changed by increasing the striking velocity to 1,100 feet per second.

If the 12-inch armor-piercing shell loaded with high explosive and fired at extreme range at which it would have an angle of fall of approximately 15° should travel 100 calibers and not penetrate more than 23 calibers below the surface of the water, it is evident that the probable damage to a battle ship would be much greater for the shell striking 100 feet short than for the shell striking the ship, assuming, of course, that the percussion fuze in the shell is adjusted not to act on water impact, which is practically the case with service fuses, which will be used. It will be borne in mind that any departure of the seacoast projectiles from the tangency to the trajectory will increase the chances for reaching the hull of a battle ship by striking the water short of the battle ship, since the increased surface of the shell striking the water would give a stronger tendency to upward deflection.

It having been correctly assumed that the dimensions of the target for a mortar shell are increased by twice the effective radius of the shell when exploded under water, the principal lesson from these experiments is that with shell fired from high-power guns the dimensions of the horizontal target may be increased 100 calibers by the shell striking short of the target. The results of the experiments with the .30-caliber bullet have in general been confirmed by firings made from the 6-pounder gun, and firings from guns of larger caliber are in progress.

CAPPED AND UNCAPPED PROJECTILES.

Under allotments from the Board of Ordnance and Fortification this Department has been conducting experiments upon deck armor of 3½ inches and 4½ inches thickness, with 8-inch, 10-inch, and 12-inch armor-piercing shell, capped and uncapped, at varying angles of impact, to determine the effect upon the armor, and also the relative value of the capped and uncapped shell in mortar firing. In these experiments the plates were required to fulfill the requirements of protective deck plates prescribed by the Navy Department. The plates were mounted on a strong oak frame and backing with the face of the plate in a vertical plane, making the desired angle with the direction of the axis of the bore of the gun, and at a suitable distance from the muzzle to interpose screens for measuring the velocity at each round. The charges used were determined to make the striking velocity in each case the same as the remaining velocity for an angle of fall equal to the angle of impact. With the 8-inch capped shell and a 3-inch plate, perforation was secured with an angle of impact of 25°. The 10-inch capped shell at 20° and the 12-inch at 15° both seriously cracked a 4½-inch plate. The results of these firings lead to the conclusion that, for relatively thin plates at least, the capped is markedly superior to the uncapped shell, even for very oblique angles of impact and relatively low velocities.

In connection with this test one 12-inch armor-piercing capped shell, charged with high explosive and detonating fuse, was fired against a 4½-inch plate, the angle of impact being 15°. The percussion part of the detonating fuse was arranged without the delay-action feature, so that it would operate with as little delay as practicable following the impact of the projectile on the plate. The effect of the shell on first striking the plate was to make a glancing indent; the projectile then moved until its base was about 12 inches from the middle of the indent, and exploded in contact with or in close proximity to the face of the plate. The explosion was a high order of detonation, and the plate was completely wrecked, the backing was nearly destroyed and moved 6 feet from its initial position, and swung round about 45°.

BREECH-LOADING SALUTING GUNS.

In my last annual report I referred to the desirability of converting 3-inch muzzle-loading guns to breechloaders for saluting purposes, owing to the occasional accidents resulting from the use of the former. During the year 20 guns have been converted and are now being issued to the service. The breech-loading guns have a sliding breechblock similar to the Hotchkiss block, and will be mounted upon cast-iron carriages arranged to be bolted to wooden or masonry platforms. The chambers have been designed to use the service 6-pounder saluting case.

The powder used in saluting charges is a potassium nitrate composition of moderate cost, and were it not for the amount of smoke going off at discharge would be satisfactory. The dissatisfaction resulting from the smoke has caused efforts to be made to substitute a smokeless powder, but so far powder makers in this country have not succeeded in their efforts to meet the wishes of the Department, owing to the occasional development of unsafe pressures. In this regard manufacturers abroad appear to have been successful, since samples of smokeless saluting powder recently obtained from them have been tested satisfactorily. The registered pressures from these latter charges were about 3,800 pounds per square inch, indicating the powder to be safe; and judged by the noise and absence of smoke it should meet all of the requirements of service, provided it has the proper stability. At present saluting charges are placed in cartridge bags of raw silk fiber, but, when the issue of the saluting guns to the service is completed, it is planned to omit the bags and to place the powder directly into the cases, holding it in place by wads.

PRINCIPAL MATERIAL UNDER MANUFACTURE, INCLUDING THAT AT ARSENALS AND AT PRIVATE MANUFACTURERS.

Material.	To be delivered.	Material.	To be delivered.
1-pounder Hotchkiss guns, 40 calibers long	10	Projectiles	148,500
2.95-inch (75 millimeters) mountain guns	36	Dummy projectiles	327
3-inch field rifles, model 1902	159	Ball cartridges, caliber .30, for artillery drill cartridges	250,000
3-inch R. F. guns, model 1903	1	Powder, pounds	504,529
5-inch R. F. guns	21	Fuses	64,000
5-inch combined R. F. and disappearing gun	1	Fuse setters	12
6-inch R. F. guns	72	Cartridge cases for fixed ammunition	113,173
6-inch wire-wrapped gun, experimental	1	Pressure cylinders for cannon	25,000
6-pounder semiautomatic guns	2	Standard star gauges	4
7-inch, .45 caliber, nickel-steel rifles for Navy	24	12-inch disappearing carriages, L. F., model 1901	4
8-inch, .45 caliber, nickel-steel rifles for Navy	24	10-inch disappearing carriages, L. F., model 1901	12
10-inch rifles, model 1900	6	6-inch barbette carriages, model of 1900	45
12-inch rifles, B. L	15	15-pounder barbette carriages, model of 1902	60
Convert wrought-iron M. L. rifles to B. L. saluting guns	120	15-pounder barbette carriages, model of 1903	1
4½-inch Krupp face-hardened steel shield	1	5-inch barbette carriages, model of 1903	21
Krupp face-hardened steel plates, 92 by 48 by 5 inches	3	6-inch disappearing carriages, L. F., model of 1903	70
		75-millimeter mountain-gun carriages	54

PRINCIPAL MATERIAL UNDER MANUFACTURE, INCLUDING THAT AT ARSENALS AND AT PRIVATE MANUFACTURERS—continued.

Material.	To be delivered.	Material.	To be delivered.
4.7-inch siege carriage	1	Cavalry sabers and scabbards	20,000
3-inch field carriages, model of 1902	208	Officers' sabers and scabbards	375
3-inch field limbers, model of 1902	832	Ball cartridges of all kinds	26,102,148
3-inch field caissons, model of 1902	624	Blank, dummy, guard, and gallery cartridges of all kinds	21,554,705
Forge limbers, model of 1902	52	Sets of infantry equipments	17,870
Battery wagons, model of 1902	52	Sets of horse equipments	7,217
Store wagons, model of 1902	52	Sets of cavalry equipments	15,173
Store-wagon limbers, model of 1902	52	Sets of artillery harness, lead, russet	1,968
3-inch objective telescopic sights, for seacoast guns	261	Sets of artillery harness, wheel, russet	1,014
Panorama sights for 3-inch field carriages, model 1902	170	Woven cartridge belts	123,100
Battery commander's telescopes	20	Sets infantry fencing equipments	700
Front and rear sights for 3-inch field carriages, model 1902	208	Sets cavalry fencing equipments	200
Range quadrants for 3-inch field carriage, model of 1902	208	Swasey depression position finders, type A	119
Sights for different caliber seacoast guns	152	Whistler plotting boards	200
Front and rear sights for 75-millimeter mountain guns	18	Pratt's ballistic boards	115
Automatic machine guns, caliber .30, on tripod mounts	90	Pack saddles for caliber .30 machine guns	600
United States magazine rifles, model of 1903	112,000	Pack saddles for 75-millimeter mountain guns	1,152
		Arm racks, model 1903 rifles	2,300
		Gunners' badges	1,700
		Pouches for first-aid packets	60,000

BETHLEHEM STEEL WORKS.

During the fiscal year the following work has been in progress at the Bethlehem Steel Works under the supervision of the inspector of ordnance at those works, Captain William H. Tschappat, Ordnance Department:

1. One 5-inch combined rapid-fire and disappearing gun and carriage, contract of July 2, 1900; shipped to the Sandy Hook Proving Ground, June 25, 1904.
2. One 6-inch R. F. gun on pedestal mount, contract of January 11, 1901; shipped to the Sandy Hook Proving Ground, June 4, 1904.
3. Ten 10-inch B. L. rifles and fifteen 12-inch B. L. rifles, contract of December 14, 1901. During the year three 10-inch rifles and three 12-inch rifles were completed and proved, completing all of the 10-inch rifles and eight of the 8-inch rifles under this contract.
4. One 4½-inch steel shield, contract of May 16, 1902; shipped to the Sandy Hook Proving Ground with 6-inch gun and pedestal mount.
5. Five shields for 6-inch R. F. gun carriages, contract of July 12, 1902; contract completed October 16, 1903.
6. One 4½-inch steel shield, contract of August 8, 1902. This shield has been under the inspection of the navy inspector. It is bent to shape but not hardened. It is to be attached to the 6-inch pedestal mount manufactured under contract of January 11, 1901. A special cradle is required to attach this shield, and its attachment will be deferred until after the preliminary firing of the gun at the proving ground.
7. Thirty 15-pounder, 3-inch R. F. guns and barbette carriages, contract of October 15, 1902. No guns or carriages have been delivered under this contract. The company is experiencing some difficulty in providing proper artificial illumination of the reticule of the telescope. One of these guns and carriages was shipped to the St. Louis Exposition March 30, 1904, and will be returned to the manufacturers for some improvements before issue. Gun and carriage No. 4 of this contract were shipped to the St. Louis Exposition by the Bethlehem Steel Company as one of their exhibits.

8. Fifty sets of nickel steel forgings for 3-inch field gun, model of 1902, contract of December 11, 1902. The thirty-two sets remaining under this contract were delivered by November 10, 1903.
9. Thirty 15-pounder 3-inch R. F. guns and barbette carriages, model of 1902, contract of December 29, 1902. Seven of these guns are completed except breech mechanism, and the material for the mounts is on hand except the counter recoil springs, shields, and sighting apparatus.
10. One dummy breech mechanism for 15-pounder R. F. gun, contract of August 7, 1903. The mechanism has been delayed on account of changes in design, but it is expected that it will be finished in a short time.
11. Fifteen sets of nickel steel forgings for 6-inch R. F. gun, model of 1903, contract of October 19, 1903. This contract expires on January 26, 1905. Four sets of forgings have thus far been delivered, practically on time.
12. Sixteen sets of nickel-steel forgings for 3-inch B. L. rifle, model of 1902, contract of December 21, 1903. This contract expired on April 1, 1904. Twelve sets only have been delivered to date.
13. Twenty sets of nickel steel forgings for 6-inch R. F. gun, model of 1903, contract of January 15, 1904. This contract expires on February 8, 1905. Four sets have been delivered.
14. One shield, complete, with shield supports, for 15-pounder barbette carriage, model of 1903, contract of May 23, 1904. This shield remains uncompleted.
15. Besides the above, work has been in progress upon miscellaneous forgings and castings required by this Department and contractors.

SCOTT FOUNDRY, READING IRON WORKS, READING, PA.

One 6-inch R. F. Brown segmental tube wire-wrapped gun and mount, contract of January 13, 1903. This construction is under an allotment from the Board of Ordnance and Fortification. On June 30 the gun had been assembled and rifled. The mount was about 95 per cent completed.

The value of the material delivered for the Department during the fiscal year was $448,517.72.

INSPECTOR OF ORDNANCE, AKRON, OHIO.

As contracts were entered into in the early part of the fiscal year with three companies in different parts of the State of Ohio for 40 6-inch disappearing carriages, L. F., model of 1903, and with other companies for miscellaneous material, an inspection office was established in Columbus, Ohio. Capt. Lawson M. Fuller, Ordnance Department, was temporarily assigned to duty as inspector until the arrival of the permanent inspector, Capt. J. H. Rice, Ordnance Department. This office was subsequently removed to Akron, Ohio, to which place the manufacture of 25 of the carriages was transferred, and has been charged with the inspection of material at the works of the following manufacturers, namely: Rarig Engineering Company, Columbus, Ohio; Morgan Engineering Company, Alliance, Ohio; Mansfield Engineering Company, Mansfield, Ohio; Wellman-Seaver-Morgan Company, Akron, Ohio; Firth-Sterling Steel Company, Demmer, Pa.;

Warner & Swasey Company, Cleveland, Ohio; Crucible Steel Company of America and Carnegie Steel Company, both at Pittsburg, Pa.

Rarig Engineering Company.—A contract was entered into on August 3, 1903, with this company for twenty 6-inch disappearing carriages, L. F., model of 1903. The first carriage was to have been delivered on February 24, 1904, and the remaining nineteen carriages at the rate of one every twenty days thereafter. The company experienced great difficuly in obtaining acceptable steel castings, which resulted in a controversy between it and the subcontractor for the castings. On account of the great delay resulting from the difficulty experienced by it in obtaining suitable material, a new contract was entered into with this company on August 5, 1904, by which the twenty carriages were to be completed by the Wellman-Seaver-Morgan Company, Akron, Ohio, and a contract was entered into on August 5, 1904, with this latter company to complete them at the original contract price. Under the terms of this latter contract the first carriage is to be delivered on September 15, 1904, and the remaining 19 carriages at the rate of one every fifteen working days thereafter.

Morgan Engineering Company.—A contract was made with this company on August 3, 1903, for fifteen 6-inch disappearing carriages, L. F., model of 1903, and on April 28, 1904, another contract was entered into for ten 5-inch barbette carriages, model of 1903.

This company has made satisfactory progress in the manufacture of these carriages. The first 6-inch disappearing carriage was completed on April 20, 1904, and shipped to St. Louis, Mo., for exhibition at the Louisiana Purchase Exposition. The second carriage was completed on August 15, 1904, and the remaining 6-inch disappearing carriages have reached such a stage of completion as to enable the company to erect and subject to the prescribed shop tests three carriages at the same time.

The major part of the material required for the 5-inch barbette carriages, model of 1903, has been delivered and the necessary jigs, templets, etc., for their manufacture completed. It is believed that these carriages will be delivered on time.

Mansfield Engineering Company.—On August 3, 1903, a contract was entered into with this company for five 6-inch disappearing carriages, L. F., model of 1903. But little progress had been made in their manufacture when the company went into bankruptcy on April 12, 1904. On June 20, 1904, an agreement was entered into by the receiver of the Mansfield Engineering Company with the Wellman-Seaver-Morgan Company, of Akron, Ohio, whereby the latter company was to complete the carriages as subcontractor, which agreement was approved by the Department. Under the terms of this agreement the first carriage is to be delivered on January 5, 1905, and the remaining four by May 1, 1905.

Wellman-Seaver-Morgan Company.—This company is completing five 6-inch disappearing carriages, L. F., model of 1903, under an agreement with the receiver of the Mansfield Engineering Company, and also twenty carriages under the contract made with it on August 5, 1904.

Firth-Sterling Steel Company.—On March 15, 1904, a contract was made with this company for 1,656 6-inch rendable armor-piercing shot, and 936 5-inch rendable armor-piercing shot. Three lots of the 6-inch shot, representing 966 projectiles, have passed the ballistic test and are now being completed. All of the 6-inch shot have been machined and treated. Four hundred and forty-five of the 5-inch shot have been machined and 275 have been forged.

The Warner & Swasey Company.—The following contracts have been made with this company, namely: February 13, 1904, 40 Swasey depression position finders, type A; February 5, 1904, ten 3-inch objective telescopic sights, model of 1904; April 18, 1904, two hundred and sixty-one 3-inch telescopic sights, model of 1904; April 18, 1904, 20 battery commanders' telescopes.

Twenty Swasey depression position finders, type A, have been delivered and the remaining 20 were, on June 30, 1904, 75 per cent completed.

On June 30, 1904, the first lot of the twenty-five 3-inch objective telescopic sights were 60 per cent finished and the remainder about 10 per cent. The contract for the 20 battery commanders' telescopes requires the company to complete and deliver 1 instrument for test prior to the completion of the remaining 19. This instrument was delivered on May 23, 1904, and is now undergoing test.

Crucible Steel Company of America.—On April 19, 1904, a contract was made with this company for 56 hardened protective shields for 3-inch field carriages, model of 1902, and 264 sets for 3-inch field caisson, model of 1902. On June 30, 1904, 3 sets of shields for the caisson had been delivered, 18 additional plates had passed the ballistic test, and about 300 additional plates were in process of manufacture.

Carnegie Steel Company.—On July 9, 1904, a contract was entered into with this company for 32 sets of hardened protective shields for 3-inch field carriages, model of 1902.

MIDVALE STEEL WORKS.

Capt. Ormond M. Lissak, Ordnance Department, performed the duties of inspector at the Midvale Steel Works, and at the works of 15 other contractors in the vicinity of Philadelphia, in addition to his duties as assistant to the commanding officer of Frankford Arsenal.

During the year the Midvale Steel Works did work under 41 contracts with the Department and ordnance establishments, and under 13 contracts as subcontractors, all of which have been completed except one. Thirty-nine of the 51 contracts with the other 15 contractors have been completed.

The principal material inspected by this office included 5,625 projectiles of different kinds and calibers, 406,600 pounds of steel, 2,973 feet of miscellaneous steel bars, 3,276 pieces of flange steel, 2,700 pounds of steel wire, 985 springs, 3,538 miscellaneous forgings for guns and carriages, and 9,971 miscellaneous steel castings.

THE DETRICK AND HARVEY MACHINE COMPANY, BALTIMORE, MD.

On August 19, 1903, a contract was made with the Detrick and Harvey Machine Company, Baltimore, Md., for fifteen 6-inch disappearing carriages, L. F., model of 1903, which were to be completed before December 15, 1904. On account of the difficulties experienced by the company in obtaining early deliveries of the material required for their construction, the first carriage was not completed and delivered until August 5, 1904. Two additional carriages are practically completed, and the work on the remainder well advanced. This company made a large number of jigs, templets, and gauges, and the quality of the work done by it has been excellent. These carriages are being inspected by Capt. Lawson M. Fuller, Ordnance Department, in addition to his other duties in this office.

THE UNITED STATES RAPID FIRE GUN AND POWER COMPANY—THE AMERICAN ORDNANCE COMPANY.

The inspection work at the United States Rapid Fire Gun and Power Company, Derby, Conn., and the American and British Manufacturing Company, Bridgeport, Conn., has been in charge of Capt. W. S. Peirce, Ordnance Department, during the year. The material under manufacture by the first-mentioned company under contracts with this department consisted principally of 15-pounder rapid-fire guns, carriages, and ammunition. About 8,000 rounds of 15-pounder steel-shell ammunition remain to be delivered, of which nearly all are machined preparatory to closing the base. The design of this shell was modified to adapt it for high-explosive bursting charges. The work was somewhat delayed by this change, but the slow progress made is considered to be due in greater part to the lack of such effort on the part of the contractors, as might reasonably have been expected. The material now in progress of manufacture at these works consists of 15-pounder steel-shell ammunition and the conversion of twenty-five 3-inch wrought-iron muzzle-loading guns to breech-loading saluting guns.

The material under manufacture during the year by the American and British Manufacturing Company has consisted of small-caliber ammunition, 1-pounder and 75-millimeter subcaliber tubes, 1-pounder

Hotchkiss guns, mounts, etc., and 3-inch field guns. The progress made by this company and the times of delivery of the material have altogether been satisfactory. This company now has on hand the conversion of seventy-five wrought-iron muzzle-loading 3-inch guns to breech-loading saluting guns, and the work has been commenced.

In addition to the material ordered by this office from the abovementioned companies, that ordered by contractors for this department and by commanding officers of arsenals has been inspected before shipment.

THE BUILDERS IRON FOUNDRY, PROVIDENCE, R. I.

A contract was made with this company on August 30, 1902, for the construction of thirteen 6-inch barbette carriages, model of 1900, and the work was inspected throughout the year by Capt. Samuel Hof, Ordnance Department.

The delay in the completion of these carriages is largely due to the difficulty experienced in obtaining steel castings that fulfilled the requirements of the specifications. The first carriage was completed on May 26 and the remaining twelve are about 75 per cent completed.

ROCK ISLAND ARSENAL.

This arsenal was commanded throughout the year by Lieut. Col. Stanhope E. Blunt, Ordnance Department, U. S. Army.

Artillery store shed.—The necessity for an artillery store shed has become urgent. As the Army and militia are equipped with the new 3-inch field material, the old material turned in should be thoroughly overhauled, repaired, and stored as a reserve supply. No building is available for this purpose. The design of a suitable storehouse has been prepared and an estimate for its construction is submitted.

Hospital.—For a number of years past an estimate has been submitted for the erection of a hospital at this arsenal to replace the wooden structure temporarily erected more than forty years ago, when the island was used for the detention of prisoners of war. This building is rotten, leaky, and unfit for housing the sick, or for any other purpose; it has been reported by the Inspector-General as utterly unfit for hospital purposes and not worth repairing. One hundred soldiers are stationed at this arsenal, and as the hospitals of the neighboring cities are from 2 to 3 miles away, it is at times imperative that emergency treatment be given workmen in the post hospital. The design of a hospital building has been prepared and an estimate for its erection is again submitted.

Stable.—The building now used as a stable is another of the old prison structures of the war of 1861–1865. It has become so rotten as to render repairs impossible, and its location is a menace to adjacent expensive buildings on account of its possible rapid destruction by fire. An estimate for a new building is submitted.

Storehouse.—The storehouse to replace the one destroyed by fire February 18, 1903, and for the erection of which an appropriation of $150,000 was made on March 3, 1903, has been designed and contracted for and should be completed by December 30, 1904. It will be a highly modern structure, with fireproof floors and partitions.

Officers' quarters.—The set of officers' quarters appropriated for in the sundry civil bill approved April 28, 1904, is under construction and it is expected will be ready for occupation before the close of the present fiscal year. Quarters for additional officers will be needed in the future, but estimate is not now submitted for them, as other necessities are more pressing, and until these shall be supplied some officers can submit to the inconvenience of living in adjacent cities.

Rock Island Bridge.—The bridge was constructed and is operated by the United States, which divides the expense with the railroad companies using it. The statistics show a continual increase of traffic over it, accompanied by a decrease of river traffic through the draw.

Water power.—An extension of the power house has been completed. Two generators of 500 kilowatts each and one of 650 kilowatts are installed, and with two exciters are operated by twenty turbines. The plant has a normal capacity of 2,200 horsepower, with permissible extreme of 3,000 horsepower. It is a beautiful and efficient installation, supplying current more than sufficient for one hundred motors, aggregating 2,364 horsepower, by which the machinery of the shops is operated.

For a number of weeks last winter, and during a shorter period the previous season, ice gorges formed in the river either below the island, backing up water in the tailrace and thus reducing the head, or in the pool, cutting off the flow of water to the wheels, and in both cases greatly reducing, and for a few days entirely stopping, the power of the arsenal plant. The probability of recurrence renders desirable the installation of an auxiliary steam-power plant to insure the uninterrupted operation of the arsenal.

It is believed to be possible to generate sufficient electrical power, in excess of the needs of the arsenal, to more than offset by its rental the cost of maintaining and operating the plant.

Arsenal shops.—The facilities of the shops have been increased during the year by the addition of 92 machines of various kinds, most of which were procured for the manufacture of new field artillery material. The hydraulic plant for the formation of parts of gun carriages by pressure has been in successful operation during part of the year. In the harness shop the principal item of new work undertaken has been the manufacture of pack outfits for mountain and automatic machine guns, for which purpose lock-stitch sewing machines have been installed and have proved very satisfactory, two doing the work of more than twenty men.

The principal new work undertaken in the equipment shop has been the manufacture of forks, knives, expert rifleman's badges, distinguished pistol-shot badges, metal parts for the new canteen and haversack attachments for woven cartridge belts, and fasteners for these belts. The installation of automatic machinery in the equipment shop has been continued; one machine requiring but little attention makes 30,000 buckle tongues in eight hours, instead of 6,000 obtained from the older machine, which required the constant attention of an operator.

One of the most important changes in the processes of manufacture during the year has been an extensive transfer from day to piece work in the carpenter and paint shops, resulting in a reduction of cost varying from 20 to 60 per cent, although the earnings of the workmen have been increased from 15 to 30 per cent as a result of the increased output.

The machine shop, forge shop, and foundry have been principally engaged during the year in the manufacture of the new 3-inch field artillery material; a pilot 4.7-inch field carriage, model of 1904; 5 6-inch barbette carriages, model of 1900; 10 combined forge and battery wagons for 3.2-inch field artillery; 81 armament chests for 7-inch siege howitzer; and models of one-tenth size of the new 3-inch field artillery material.

The first 3-inch field carriage, model of 1902, was completed and proof fired last December. Eighty-four carriages and limbers will be completed by December 31 next, and the remaining 34 prior to the close of the next fiscal year.

The machine shop has been operated sixteen hours per day during practically the entire year, using for that purpose two shifts of machinists and machinist's helpers. It has been found necessary to introduce a number of new processes to obtain that degree of accuracy and interchangeability of parts required in the manufacture of the new field artillery material, which has been accomplished in a highly creditable manner. A hydraulic plant, consisting of a triplicate vertical pump and two hydraulic presses, having a capacity of 344 and 1,700 tons, respectively, has been installed and excellent results obtained with it in the forming of parts having irregular shapes out of flange steel. The machining of the interior of the recoil cylinder is a difficult and complicated operation, due to the comparatively inaccessible surfaces and to the accuracy of finish required. These surfaces have been finished with such nicety that the maximum variation from prescribed dimensions in many cases does not exceed 0.0008 of an inch. The axles for the carriage, limber, and caisson are hollow, with the bore larger in the middle than at either end, and are made from a single piece of forged steel. The axles were at first purchased from private manufacturers, but as a result of the improved methods adopted at the arsenal they are now made for less than one-half of the price for which they were purchased in the market. An unsuccessful effort has been made to manufacture counter-recoil springs for these carriages; experiments with that end in view will, however, be continued.

The year's output of equipments has been the equivalent of 16,000 sets of horse equipments, 25,000 sets of cavalrymen's equipments, 70,000 sets of infantry equipments, harness for 17 field batteries, and sundry pack outfits for mountain guns.

Over 2,200 workmen are now employed at this arsenal, and this number will be gradually increased during the coming year as the small-arms plant is more fully operated.

Drafting room.—During the year the following material has been designed and detailed drawings thereof prepared, namely: Battery wagon and forge limber, model of 1902; store wagon and store-wagon limber, model of 1902; 3.8-inch field carriage; pack outfits for 75-millimeter Vickers-Maxim mountain gun, for Colt's automatic machine gun, and for Vickers-Maxim automatic machine gun. In addition a large number of drawings for handbooks, working drawings for use in the shops, and drawings of the equipments made at this arsenal have been prepared. Twenty-three draftsmen are employed—an increase of over 100 per cent during the year.

Small-arms plant.—During the year 81 machines have been installed, making a total of 1,155 machines in this plant. The fixtures, dies, jigs, tools, etc., required for the completion of the plant are being manufactured at the Springfield Armory and will be completed during the present calendar year. It being essential that all parts of the rifles manufactured at Rock Island Arsenal and at the Springfield Armory should be strictly interchangeable, all gauges will continue to be made at the latter place. It is anticipated that the installation of this plant will be completed and that a daily output of 125 finished arms will be obtained by or before June 30, 1905.

A number of foremen, inspectors, and skilled mechanics have been either permanently or temporarily transferred from the Springfield Armory to this arsenal, in order that their experience and training may be utilized in starting machine operations and in the instruction of inexperienced men. Of the 90 component parts contained in the United States magazine rifle, model of 1903, the machine operations on three of the parts have been completely installed and those on 32 partially installed.

Proving ground.—To enable the field, siege, and mountain-gun carriages manufactured at this arsenal to be proof fired, a small proving ground has been established on the eastern end of the island. The surrounding country is so thickly settled that range firing can not be had. By the construction of suitable butts, however, all carriages can be safely proof fired, thereby saving the cost of their transportation to some other point for that purpose, and familiarizing the manufacturing personnel with their performance.

Reports on material.—During the year boards of officers have investigated and reported upon the following material, namely: Pack outfit for Colt's automatic gun; gun rack and protector proposed by N. Reifal Gill & Sons; canteen with filter and pump, submitted by Thomas Kearns and T. C. Coin; McNeal's support for cavalry pack; Colonel Patterson's device for carrying rifle by mounted troops; equipment pack designed by Major Kirkpatrick and Captain Bradbury, of the Ohio National Guard; aluminum equipment kit proposed by Major Abercrombie, U. S. Army. The tests for determining the tractive force required for various widths of artillery tires on different kinds of soil and roads were concluded.

SPRINGFIELD ARMORY.

The armory has been commanded during the year by Col. Frank H. Phipps, Ordnance Department.

It is the principal small-arms factory of the Department, and is now turning out rifles at the rate of 300 per day, which rate is expected to be increased shortly to 400 per day. The buildings and grounds are in good order and the entire plant is in a high state of efficiency.

Manufactures.—The following principal arms were manufactured during the year: 47,927 United States magazine rifles, caliber .30; 2,245 officers' sabers; 48,868 bayonet scabbards for United States magazine rifle, model of 1898; 15,623 stocks for issue as spare parts.

There were repaired during the year 3,279 United States magazine rifles and carbines, caliber .30, together with a large number of Springfield cadet rifles, cavalry sabers, scabbards, bayonet scabbards, and machetes. Many rifle appendages and miscellaneous spare parts have also been manufactured.

The following stores were inspected and received from manufacturers during the year: 13,650 Colt's revolvers, caliber .38; 40 Gatling guns, caliber .30, model of 1903; 100 Winchester repeating shotguns, 12 gauge, model of 1897, and 115 fixtures for the manufacture of United States magazine rifle, model of 1903, at Rock Island Arsenal, have been purchased and inspected. Two hundred and forty-nine fixtures, 915 gauges, and 27 jigs for the same arm have also been made for the Rock Island Arsenal small-arms plant.

Machines.—During the year 100 machines of various kinds, one electric generator, and one 40-horsepower motor were purchased and installed. Twenty-seven machines have been repaired and altered. Seventeen machines have been manufactured at the armory.

United States magazine rifle, model of 1903.—As the fixtures, gauges, tools, etc., required for the manufacture of the United States magazine rifle, model of 1903, progressed, the manufacture of the model of 1898 rifle was gradually decreased until November last, when it ceased. The manufacture of the model of 1903 rifle has steadily progressed, the daily output being gradually increased as the completion of the fixtures, tools, gauges, etc., would permit, until a daily output of 300 rifles per day of eight hours was obtained. This output will be gradually increased to 400 rifles per day of eight hours, which output, it is anticipated, will be obtained in November next.

Experimental firings.—An experimental firing range was established near Fort Clark, Tex., last January, and a series of firings conducted for the purpose of verifying the elevation graduations on the rear sight, and for obtaining the accuracy, drift, and deviation of the bullet due to a 1-mile wind at each 100 yards range up to and including 2,000 yards. The results of these firings are now being worked up and will be included in the next edition of the description and rules for the management of the new rifle which is now being prepared.

The firings made on this range were conducted by Maj. W. C. Brown, Fifth Cavalry, to whom great credit is due for the results obtained. The firings, extending over a period of seven months, showed that the barrel of the new rifle is, as was anticipated, more rapidly eroded and worn than those of any previous model.

The erosion of the bore, which occurs principally at the seat of the bullet, is due to the chemical and mechanical action of the gases emerging from the cartridge shell at a high temperature and under a pressure of about 49,000 pounds per square inch. Experiments are being made for the purpose of obtaining, if possible, a barrel steel which will more effectively resist this action of the powder gases. Experience so far shows that erosion increases with the percentage of carbon contained in the steel, and also in the case of nickel steel, with the percentage of nickel. The erosion in barrels made of nickel steel is greater than in those made of simple carbon steel.

Telescopic sight.—Different forms of telescopic sights have been tested during the year with a view to obtaining a suitable design for issue to expert riflemen. The only promising design so far obtained is one made by the Warner & Swasey Company, of Cleveland, Ohio, which is now being tested.

Two different designs of devices for attachment to the muzzle of the United States magazine rifle, model of 1903, to decrease the effect of the energy of recoil, were tested. Although both accomplished their object, they increased the sharpness of report to such extent as to render them more objectionable than the recoil. Each also had other defects which rendered it unsuitable for the military service.

The number of employees in June, 1904, was 1,390, and the total expenditures for the fiscal year ending the 30th of that month were $1,483,441.18.

FRANKFORD ARSENAL.

This arsenal has been commanded during the year by Lieut. Col. Frank Heath, Ordnance Department. It is the Department's factory for ammunition of all classes for small arms, for ammunition for field and siege artillery, and for seacoast artillery for caliber up to 6 inches; for gauges and inspecting instruments, and instruments for the control and direction of the fire of seacoast artillery, and for various other classes of tools and implements. Daily tests are made of the velocity and accuracy of the current output of ammunition for small arms; also tests for the waterproof quality of the ammunition, and for its comparative accuracy in competition with that produced by private manufacturers. The operations of the establishment include much preparation for issue of ammunition of all kinds, and the breaking up and remanufacture of old ammunition.

The plant has been considerably enlarged since the Spanish war, 147 new machines having been added during the past year, and has now a capacity of about 150,000 rounds of small-arms ammunition per day; 700 artillery cartridge cases for guns of about 3-inch caliber, or the equivalent of this; 200 fuzes per day; 150 shrapnel per day, ultimately to be increased to 400 per day; besides sights, implements, and other miscellaneous articles. The new power plant referred to in my last annual report is now in operation and furnishes power to all departments at the arsenal which are motor driven. The motors are connected to the shafts by Renold or Morse silent chains, and in some cases new-process rawhide pinions with cast-iron gears have been used. The group system of driving is employed in all departments, except in the carpenter shop, where each machine has its individual motor, belt connected. The box-making and packing shop referred to in my last annual report was completed during the year and is now in satisfactory operation. Heat, light, and power are supplied to this building from the lower plant. The space obtained by the removal of the power plant to its new building has been utilized by the concentration of the operations on lead slugs for the bullet and for the installation of 72 additional machines.

SHRAPNEL PLANT

A building for the shrapnel plant has been completed during the year. The shafting and motors are in place and the shop is ready for the installation of the machinery.

The main work of this plant has been the manufacture of shrapnel for the 75-millimeter mountain and the 3-inch field guns. The shrapnel so far manufactured have been of the hexagonal steel case type, steel jacketed balls, with compressed base charge. It is proposed, however, to change the design of these shrapnel to one in which the case has a fluted interior and the balls are not steel jacketed.

FUZE DEPARTMENT.

Experiments have been continued during the year with centrifugal fuzes, the object sought being the development of a design embracing conditions of absolute safety in handling and transportation and certainty of action. In the case of fuzes whose action depends upon longitudinal stresses developed by the pressure of the powder gases in the gun on discharge, the conditions of safety in handling and certainty of action are opposing ones. It is impossible to meet both conditions in some cases, the stresses developed in the direction of the axis by the accidental dropping of the fuze being often higher than those developed in the gun at the time of discharge. The rapid-fire conditions and the advent of high explosives, as a shell filler, have tended to include fuzes which depend for their action upon the acceleration of the projectile in the gun except in cases where the acceleration is so great that a very high-arming resistance can be given. A fuze depending upon centrifugal forces is the natural solution of the problem, and it is proposed to use such fuzes for all calibers of projectiles inclusive of and above 2.95 inches.

Three types of centrifugal fuzes have been developed, the "F," the "S," and the "12 M." The "F" fuze is for use in detonating fuze stocks already on hand. The "S" plunger is for use in all field, siege, and seacoast projectiles, excepting the 12-inch mortar. It arms at from 2,000 to 3,000 revolutions per minute, depending upon the gun in which it is used. The "12 M" fuze is for use in torpedo detonating fuze stocks now on hand, but the plunger is not as heavy as it should be. A new design of fuze carrying a very much heavier plunger than the "12 M" is being prepared. The plunger of this fuze will be of the service centrifugal pattern, arming at 1,300 revolutions per minute. It is expected that the energy of the blow of the firing pin of this plunger will insure certainty of action under the most severe conditions.

The following ring resistance fuzes are issued to the service: The "high C," the 1.65 inch, and the 1-pounder fuzes. These fuzes are very safe under all conditions of handling. The "high C" will not be issued when the stock on hand is exhausted. It will then be superseded by the centrifugal fuze "S."

Combination fuzes.—Investigations in connection with the development of a proper combination fuze have been continued during the year. Difficulty has been experienced in securing a powder and a method of insertion of the same that will secure a uniform rate of burning both at rest and in flight. The rate of burning is very much influenced by the ingredients of the powder used, amount of ventage given the gases of the burning train, and the pressure at which the train is inserted. The concussion plunger of the Frankford Arsenal twenty-one-second fuze is of the ring-resistance type, while the percussion plunger is of the service centrifugal type, arming at 2,500 revolutions per minute. These elements have both been tested and have given entirely satisfactory results. Twenty thousand fuzes have been purchased abroad for use while developing a satisfactory one at home.

Primers.—Important changes have been made in the primers used in the cartridge cases for fixed ammunition and separate-loading guns, the object of the change being the use of a primer having sufficient energy to thoroughly ignite smokeless-powder charges and render unnecessary the use of the objectionable igniting charges of black powder. As a result of experiments four primers have been developed and adopted—the 110-grain percussion primer, the 110-grain igniting primer, the 20-grain percussion primer, and 20-grain igniting primer. These primers cover all that are used in cartridge cases for artillery ammunition. A 110-grain electric primer has also been adopted for use in the same cases where the 110-grain primers above mentioned are used. For use with saluting charges a 20-grain primer has been adopted and is made of such dimensions that it can be used in cases for 6-pounder guns and those of higher caliber.

ARTILLERY CARTRIDGE PLANT.

This plant is equipped to manufacture all sizes of cartridge cases at present used in the service, and has been in satisfactory operation during the year. About 93,000 cases have been manufactured.

SMALL ARMS CARTRIDGE PLANT.

There were manufactured during the year 55,906,250 small-arms cartridges of all kinds.

During the year Capt. Ormond M. Lissak, Ordnance Department, continued to devote much time and attention to the designing of automatic machinery for use in the manufacture of small-arms cartridges. As a result of his efforts a number of automatic machines have been perfected and installed, which not only decreases the cost of manufacture, but also the amount of floor space required for a given output. Among the machines devised by him and installed during the year are the following: A machine which inserts the springs into the cartridge clips at a rate of 9,000 per day and which performs the work of 9 hand operators; a machine which inserts the cartridges into the clips and turns down the clip springs over the cartridges at a rate of 28,000 cartridges per day. It requires 2 operators, but does the work of 5 hand operators. The attachment of an electric device to the primer inserting machine which indicates by the ringing of a bell the presence of a cartridge in the machine in which the vent has not been made. New mouth-trimming machines of an improved design have been perfected and installed. A new double-acting press for the forming at one time of three cups for the cupro-nickel bullet jacket will be installed at an early date.

The application of automatic feed hoppers to different small arms cartridge machines has been continued during the year, and has increased the capacity of each machine from 10 to 18 per cent, and enables one operator to tend two or more machines.

Ball cartridge, model of 1903.—The manufacture of the cartridge for the new rifle has progressed satisfactorily during the year.

Efforts are also being made to develop a more suitable powder for this cartridge in order that the maximum pressure may be reduced.

Caliber .38 cartridge.—The experiments conducted for developing a primer which would fulfill the conflicting conditions imposed upon it by a revolver having a 6-pound trigger pull in single action and a 12-pound trigger pull in double action have been concluded and a satisfactory primer adopted.

Sights for 3-inch field material.—Front and rear sights and range quadrants for two hundred and eight 3-inch field carriages, model of 1902, are being manufactured at this arsenal. In order to complete these articles at an early date, 33 machines have been installed and two shifts of workmen employed.

Plotting boards.—The manufacture of 200 Whistler plotting boards and 115 Pratt ballistic boards has been undertaken, necessitating the installation of 7 machine tools.

WATERVLIET ARSENAL.

This arsenal was commanded from the beginning of the last fiscal year to July 13, 1903, by Lieut. Col. Charles Shaler, Ordnance Department, U. S. Army, and from that date to the end of the fiscal year by Lieut. Col. D. M. Taylor, Ordnance Department, U. S. Army. It is the army gun factory, manufacturing a large percentage of the cannon of all sizes used in the military service, as well as a number of miscellaneous articles, such as spare parts and gun carriages, the latter to employ some temporarily available machines and relieve the Watertown Arsenal. There were in June last employed 490 workmen, and the expenditures for the fiscal year 1904 were $705,165.93.

New machines in the seacoast gun shop have been arranged with a view to the use of an electric motor drive throughout the shop. The more important machines have been equipped with individual motors and the minor machines have been arranged so that one motor may drive a group. The method of power transmission heretofore used has been exceedingly inefficient. The system of electrical distribution, therefore, promises increased economy, light, and cleanliness, and decreased danger of fire, breakdown, and personal injury. The electrical equipment of the machines involves a consideration of the source of power for the purpose. This Department has under consideration the supply of power from the Hudson River Electric Company in the form of alternating current.

Improvement in shop methods has been secured during the year, and the necessary changes are proceeding as rapidly as funds will permit; they have resulted in much economy and efficiency. Experiments are now under way with a view of grinding all shrinkage surfaces of gun forgings. This has for its chief object the elimination of faults in shrinkage work, but it is also believed that the work will be done more economically. The use of grinders has been otherwise considerably increased. Special attention has been given to the tool-room department. Formerly each division of the gun shop made at least part of its tools, and working jigs were not in general use. A number of experienced tool makers have been secured, and all work of this kind is being concentrated under one head. The increased use of working jigs has resulted in more accurate interchangeability of parts and generally in economy of labor. High-speed cutting steels are now in general use, and all new brands are being given a conscientious trial. The alloyed steel has made a great saving in the cost of roughing work, but the most valuable results have been obtained from the use of finishing steels containing a high percentage of carbon with some tungsten. These not only permit of finishing at higher speeds, but hold their keen cutting edge for a long time. In keeping the plant modern and up-to-date 30 new machines have been introduced during the year.

The work at this arsenal has been increased during the year by the introduction of work for the Navy Department, 24 guns each of 7-inch and 8-inch caliber being under manufacture at that place. The work of machining these guns was commenced on March 3, 1904, and has since proceeded uninterruptedly. It was estimated that the entire number will be completed within thirty months after the receipt of the forgings therefor, and it is hoped that with care and industry the estimate may be met.

In the field and siege gun shop additional floor space has been secured by the removal of the railroad track which formerly ran the full length of the gun shop. This, with minor changes in the location of various machines throughout the shop, promises to afford increased facilities for doing work, the necessity for which has existed for some time.

The lower shops have been principally engaged in the manufacture of spare parts and tools for seacoast and rapid-fire guns, and in addition many armor-piercing shot and shell have been altered in accordance with the latest drawings.

The manufacture of 200 carriages for 2½-inch bronze Lyle life-saving guns has been undertaken for the Treasury Department and 50 carriages and 200 quoins have been completed.

The output of work from the seacoast and siege and field gun shops during the year was equivalent to two 12-inch rifles, nine 10-inch rifles, seven 6-inch rapid-fire guns, sixteen 5-inch rapid-fire guns, forty-four 3-inch field guns, forty-eight 2.95-inch Vickers-Maxim mountain guns, and six barbette carriages.

WATERTOWN ARSENAL.

This arsenal was commanded by Col. John G. Butler, Ordnance Department, until retired as a brigadier-general on January 22, 1904; by Maj. Frank Baker, Ordnance Department, until March 26, 1904, upon which date Maj. Ira MacNutt, Ordnance Department, the present commanding officer, assumed command.

The arsenal has been principally engaged during the year in the manufacture and issue of stores for the seacoast armament, requiring for that purpose practically the full capacity of the plant. The following carriages have been completed during the year, namely: One 12-inch disappearing carriage, L. F., model of 1901; two 6-inch barbette carriages, model of 1900; forty-six 75-millimeter mountain gun carriages, and one modified Spiller mortar carriage for testing 12-inch mortars.

Work is now in progress on other carriages as follows, namely: Fifteen 6-inch disappearing carriages, L. F., model 1903; three 12-inch disappearing carriages, L. F., model 1901; twelve disappearing carriages, L. F., model 1901; fifteen 6-inch barbette carriages, model of 1900; thirty-six 75-millimeter mountain gun carriages, and altering of one 12-inch mortar carriage, model of 1896, in accordance with the design prepared for strengthening the racer to permit the mortar to be fired at an elevation of 70°.

As the difficulty experienced in previous years in promptly obtaining satisfactory steel castings of small and medium size for repairs and for new work continued to greatly delay the completion of work in hand, and as the delay in obtaining small steel castings required for repairs of the armament resulted at times in serious embarrassment, a small steel casting plant, including a 2-ton converter, was installed, and has been in use since March 25, 1904. Although a few additional parts are required to complete this plant, such as a sand blast for cleaning castings and a core room and oven, excellent results have been obtained from it. Prior to June 30, 1904, 70 heats were made, amounting to 140 tons. The castings and ingots have shown excellent physical qualities and appear to be sound.

Foundry.—The wooden crane way, roof, stairway, and other parts of this building render it liable to fire, three of which have occurred during the past year. These parts should be replaced by fireproof iron constructions, an estimate for which is submitted.

Blacksmith shop.—The old engine in this shop having become worn-out, has been replaced by a motor. Four new blacksmith forges have been installed, but the increased work in this shop requires several additional hammers and other tools. The same delay experienced in promptly obtaining satisfactory steel castings for repairs and new work has also been experienced in the case of steel forgings. The increase of the forging capacity, so as to utilize available space and power and to better supply the needs of the machine plant, is desirable.

Coincident with the increase of the forging capacity, a change in the forge shop from coal to gas or oil may be found expedient, since the latter fuels are more economical.

Machine shop.—The operations in this shop during the year have been much hampered by the lack of the proper facilities for handling large work. This will be shortly remedied for the larger machine tools and for the erecting shop by the installation of electrically driven traveling cranes, for which an appropriation is now available. The remedy provided for the erecting shop, however, is only partial, since the width of the building is so great and the walls so weak that it is not possible to install therein a crane capable of handling a 12-inch gun. A proper system of hoists, trolleys, and trolley beams, operated by compressed air or electricity, should be provided, and has been estimated for.

High speed tool steel has been used in the shops through the year. While the increased amount of metal removed by it compared with the old tool steel is very marked, the conditions existing in this shop are such that full advantage of this new steel can not be secured. The width of the pulleys on the main line of shafting and counter shafts, also on many of the machine tools, is not sufficient to permit the required power to be transmitted. The most suitable method of driving the larger machines is by the use of individual motors.

The installation of the steel-casting plant, of the miscellaneous motors throughout the shops, and the contemplated installation of new electric cranes will render it necessary in the near future to provide a larger source of electric power, at which time individual motors should gradually be applied to the larger machines.

Carpenter shop.—The present building is now divided into two parts, the pattern shop and the carpenter shop. Its capacity is not sufficient to permit the employment of the number of pattern makers required for the current work of the arsenal; in fact, it is barely sufficient for that of the pattern shop alone, and provision should shortly be made for a new carpenter shop.

Transportation terminal facilities.—A large expense connected with the administration of this arsenal is due to the inadequate facilities for loading and unloading shipments and for the transportation of large parts between shops. The moving of large flasks and railroad cars in the siding is done by capstan and horse; heavy parts of carriages are moved to and from the carriage store shed by gangs of men using skids and rollers. The estimate submitted last year for the purchase of machine tools at this arsenal included a locomotive crane, but the appropriation made did not permit of its purchase; an estimate for a locomotive crane, together with other machines and tools, has been submitted.

The new barracks have been completed and were occupied on December 1, 1903.

Testing department.—In the testing department, the examination of the metal in streaked hoops has been continued, comprising hydrostatic tests of thin sections, mandrel tests on rings of the full thickness of the hoops from which they were taken, and tensile tests of the metal in both tangential and radial directions.

Tests were made to determine the resistance offered by cupronickel jacketed bullets to being forced through the bore of caliber .30 rifle barrels.

Bullets of one-fourth, three-eighths, and one-half inch length of bearing surface were forced through service barrels rifled with a uniform twist of one turn in 8 and 10 inches.

The force required to initially deform the bullets by the lands was markedly uniform. The resistance increased with the bearing length of the bullet and was generally greater with the 8 than with the 10 inch twist.

The work required to force a bullet with ½-inch bearing length through bores having a 10-inch and 8-inch uniform twist was found to be 38 and 42 per cent, respectively, of the total calculated muzzle energy of the bullets and work expended in forcing the bullet through the bore. This shows that less than two-thirds of the total work done by the powder gases in the bore is efficiently utilized. The report of these tests forms Appendix II hereto.

Recognizing the general engineering interest which attached to the strength of concrete in plain and reinforced construction, the class of industrial tests carried on by the testing laboratory has included a number of concrete columns. These columns are of such proportions as to require considerable part of the capacity of the larger testing machine in carrying their tests to destruction, and represent material in constructive sizes on engineering and architectural work. Brick piers have been tested representing the varied products of this industry as found in the New England and eastern New York yards. A number of these full-sized members, together with wooden posts, representing the chief building materials of the different sections of the country, were forwarded, after testing, to St. Louis, Mo., and form a part of the testing machine exhibit at the Louisiana Purchase Exposition.

Tests to determine the endurance of metals subjected to alternating stresses under the conditions of rotating shafts transversely loaded have been continued during the year. The results show that the number of rotations that can be made before rupture increases very rapidly as the ratio of the load applied to the tensile strength of the metal tested is decreased.

NEW YORK ARSENAL.

This arsenal, commanded by Col. John E. Greer, Ordnance Department, being mainly a purchasing and shipping agency, has no facilities for manufacturing, and its operations are necessarily those of buying, receiving, and issuing stores for the Army and militia. It also receives through the custom-house such stores as are purchased abroad. For these purposes it is of much convenience, being in the locality which affords the best market for many of the stores which must be purchased, and of easy access from the wharves of trans-Atlantic steamers. None of the above uses can be said to constitute it an indispensable establishment of this Department in time of peace. A very serviceable use for it is as a site for quarters for certain officers having duties at the proving ground at Sandy Hook; there are no quarters for these officers at the place of their duty, and to provide them would interfere with arrangements of the Department with reference to the proving ground, which are believed to be of importance. The officers concerned are of rank and service such as to entitle them to the consideration of comfortable quarters for their families, and the existence of the arsenal at Governors Island permits the provision, without imposition upon another department for erection and maintenance.

The strongest reason for the existence of a depot of the Ordnance Department upon Governors Island is the necessity for maintaining at that point a place of storage for the ordnance supplies which would be needed to equip a military expedition in time of war. The plans for Governors Island contemplate its use as an outfitting point, and as such all the supply departments of the Army have need of shipping, receiving, and storage facilities upon its territory.

The commanding officer of the arsenal is also the ordnance officer of the Department of the East, and is in addition the armament officer of the central district, whose duty it is to maintain in efficient condition the armament of the coast defenses from New York to Fort Monroe, inclusive.

AUGUSTA ARSENAL.

This arsenal, which is the headquarters of the southern armament district, has been under the command of Lieut. Col. D. A. Lyle, of the Ordnance Department. It is the depot of supplies for ordnance and ordnance stores to the troops stationed in the South Atlantic and Gulf States. Like San Antonio and Benicia arsenals, but little manufacturing is done there, but a great deal of repair work has to be done either by workmen there or by men sent out from there under the direction of the commanding officer to repair seacoast guns and carriages in place in the batteries along the coast. This brings varied and multifarious duties on the single officer there stationed, who frequently must be absent inspecting work at a distance. His force consists of a detachment of enlisted men and 17 civilian employees, with 11 machinists for the work above described.

This arsenal is the only one left in the entire South, east of the Mississippi, and the nearest constructing arsenal is nearly 800 miles distant. The location is one of the best in the South, both geographically and in its rail and water facilities, for the reception and distribution of supplies for the South.

In a memorandum of April 22, 1904, made for the Secretary of War at the call of the Senate April 13, 1904, the Chief of Ordnance drew attention to the advantage of expanding the work, both here and at Benicia Arsenal, to keep constantly in operation the metal-working and carpenter shops and their accessories in the interests of repair work, which, although insistent, is always spasmodic. This can best be done by assigning to these arsenals the manufacture to a moderate extent of such ordnance stores and parts of ammunition as can be advantageously produced thereat, and can be temporarily laid aside at any time to take up the repair work found necessary in the maintenance of the armament.

This at Augusta Arsenal would require only the development of its already existing facilities to permit the performance of work of a more general class than is at present possible and the employment of about fifty mechanics and laborers. An approximate estimate of cost for this change would be $50,000.

For full utilization of the plant of buildings and ground belonging there to the Government, and the employment of about two hundred mechanics and laborers, no additional shop buildings would be needed. Those there at present, some of which were built by the Confederate government, would suffice, requiring merely some accessory structures and a set of quarters for an additional officer. The principal outlay required would be for the machines and appliances, boilers, engines, and dynamos for the power plant, and this might be covered by an outlay of about $200,000.

No estimates have been submitted for either of these plans, and an existing objection to either of them would be the embarrassing shortage of officers referred to in another part of this report.

Attention is invited to previous reports, where it was pointed out that receipt and shipment of supplies would be facilitated by the construction of a sidetrack connecting with the electric railway, and by the installation of electric power to a moderate degree; also to the need of building new barracks for the enlisted men, the installation of a modern system of sewerage, and increasing the water supply.

BENICIA ARSENAL.

This is an arsenal of storage, issue, and repair. The ordnance supplies stored here are for the use of the troops of the Pacific coast stations and the fortifications of that coast, as well as, to a certain extent, for troops in the Philippine Islands. The arsenal was commanded from July 1, 1903, to July 20, 1903, by Lieut. Col. John E. Greer, Ordnance Department, U. S. Army; from July 21, 1903, to September 7, 1903, by Capt. D. M. King, Ordnance Department, U. S. Army; from September 8, 1903, to March 15, 1904, by Maj. Ira MacNutt, Ordnance Department, U. S. Army, and from March 16, 1904, to the end of the fiscal year by Capt. D. M. King, Ordnance Department, U. S. Army.

The commanding officer is also the ordnance officer of the Department of California and the armament officer of the western armament district. The armament in his charge is that of the Pacific coast fortifications and light batteries stationed in the Pacific division. For keeping these in repair and for making alterations and improvements shops are maintained at the arsenal, employing in June last 59 workmen. Workmen are also sent out to fortifications upon this coast. The expenditures during the fiscal year 1904 were $92,813.58.

During the year a considerable amount of target material was manufactured; also material for the repair of armament. A gas engine and several new machines were installed in the shops, and two powder magazines of large capacity were built. A material proportion of the work of the arsenal consists of the preparation of cartridges for issue.

UNITED STATES POWDER DEPOT.

This depot has been commanded during the year by Maj. O. B. Mitcham, Ordnance Department, U. S. Army. It is a place for the storage and issue of ammunition of all kinds for the seacoast and light artillery service, and for such preparation of the ammunition as is not effected at its place of manufacture. The number of employees was, in June last, 128. The expenditures for the fiscal year 1904 amounted to $163,982.11, largely for new construction.

The plan of the board of officers for the enlargement of the facilities of the depot for the preparation and issue of ammunition and ordnance stores, referred to in my last annual report, has been followed during the year, and progress has been made.

An examination of the boundary lines of this reservation, amounting in all to approximately 13 miles, an inclosure of 1,551 acres, was made during the year and showed much of the fencing in bad order and stone monuments marking the corners in bad condition. In some cases the monuments had entirely disappeared. To insure accuracy in replacing the fences and boundary stones it will be necessary to resurvey the reservation.

The increased amount of work to be carried out at this place, involving additional boilers, engines, and machinery, requires consideration of an ample water supply. The springs on the hills on the eastern part of the reservation, which have heretofore supplied the reservoirs, are now being opened up and properly housed, in order that as much water as possible can be obtained.

During the year the loading house for high explosives and the boiler house connected therewith were completed, and the press has had its acceptance trial. Certain minor improvements and changes will be required before the plant will be ready for entirely satisfactory operation.

The number of issues of powder and projectiles for the year amounted to 490, involving a total weight handled of 4,906,245 pounds.

MANILA ORDNANCE DEPOT.

The depot was commanded during the year, until May, 1904, by Maj. A. H. Russell, Ordnance Department, and during the remainder of the year by Capt. E. B. Babbitt, of the Ordnance Department, with a short interval during which it was commanded by his assistant, Capt. Kenneth Morton, Ordnance Department. Captain Morton was on duty at the depot throughout the year, and Capt. John H. Rice, Ordnance Department, was on duty there from the beginning of the fiscal year until August 20, 1903.

This depot performs a very important office, since it is the one point of supply of ordnance stores for troops in the Philippine Islands, and has shops for repairing unserviceable ordnance stores turned in by troops and for manufacturing limited quantities of ordnance stores.

No material changes in the administration of the forces of the Ordnance Department there have occurred since the rendition of the last annual report. The commanding officer of the Manila Ordnance Depot has continued to hold the position of the chief ordnance officer of the Philippines Division.

The lines of communication in the Philippines are such that it is found much more satisfactory to supply separate organizations of the troops directly from the Manila Ordnance Depot than to make use of substations at various points in the islands, temporary and occasional exception being made where active operations are going on, particularly during the campaigns against the Moros in Mindanao. In the Departments of the Visayas and of Mindanao many of the stations are less accessible from the headquarters of their respective departments than from Manila.

SALES AND TRANSFERS TO OTHER MILITARY DEPARTMENTS, THE UNITED STATES NAVY, AND THE PHILIPPINE CIVIL GOVERNMENT.

During the past fiscal year, as in previous years, the Ordnance Department has been called upon from time to time in cases of emergency to furnish stores to other military departments, to the United States Navy, and to various departments in the Philippine civil government, settlement for the money value of these stores being made either by direct payment at the ordnance depot or by transfer made in Washington between the funds belonging to the corresponding appropriations. The proceeds of all such sales for which settlement was made at the Manila Ordnance Depot during the fiscal year is $1,502.11.

SETTLEMENT OF OUTSTANDING ACCOUNTS BETWEEN THE PHILIPPINE CIVIL GOVERNMENT AND THE ORDNANCE DEPARTMENT.

The outstanding accounts noticed in previous reports as outstanding between the civil government of the Philippine Islands and the Ordnance Department for stores furnished to the Philippine constabulary. have been closed by order of the Secretary of War, pursuant to an act of Congress authorizing such settlement. The value amounted to $119,622.23, and as an offset to this all the material and stores purchased from public civil funds and previously turned over to the Ordnance Department are permanently transferred to that department. A large proportion of this property is useless, and it will be submitted to an inspector with a view of its condemnation.

SALES OF ORDNANCE STORES TO OFFICERS.

A branch of work here, which is of great convenience and benefit to officers, is that of sales of arms and equipments, and repairs to their military equipment. The proceeds from such source during the year amounted to $9,893.27.

POWER PLANT.

During the year the new power plant, much needed at the Manila Ordnance Depot, has been received, and it is now in course of installation, consisting of new boilers, an engine of 75 horsepower, a dynamo, and motors. It is proposed to provide from its power the electric light necessary for all buildings connected with the depot, and the capacity of the plant will be sufficient to meet all emergencies, even if the number or size of the buildings is increased. Electric power will be used also for running machines in the shops, and it is believed that great benefit will result from substituting this source of power, which can be applied separately to individual machines, for the complicated and antiquated shafting and gearing involved in the old Spanish power plant in use heretofore. The depot has been dependent upon private electric works in the city of Manila for its supply of electricity. This was uncertain, expensive, and intermittent, and was sufficient only for illuminating purposes. The old machinery will be sold.

Material for a nickel-plating plant has also been received, consisting of electroplating dynamo, motor, etc.

NEW OFFICE BUILDING.

During the last session of Congress an appropriation of $16,000 was made for completing the office building in process of erection and unfinished when Manila was surrendered by the Spanish. This will probably reach completion during the present year and will allow removal of the offices from the rooms now occupied in the quadrangle inclosing the shops, leaving the vacant space to be added to the shop room.

SHOPS.

The depot is provided with armorer, saddler, carpenter, blacksmith, and machine shops, tin shop and foundry, and the space gained from the old office rooms will suffice for little more than the needed expansion of these shops for present work and the addition of the nickel plating plant already referred to.

EXPANSION REQUIRED FOR SEACOAST DEFENSE.

Congress appropriated last year $418,000 for beginning the work this year of the armament of fortifications in the insular possessions, and estimates are made this year for $1,511,979 more, including $15,000 for alterations and repairs of armament and for machines to do this work at the Manila Ordnance Depot.

The distance of the Philippines from the United States precludes the possibility of sending heavy parts of armament home for repair, and makes it imperative to provide means for promptly repairing these and smaller parts at the Manila Ordnance Depot and in some instances at the batteries themselves. This will require considerable further expansion of the machine shops of the depot and the extension of the limits of the depot grounds. Recent proclamation of the President has set aside two strips of ground, embracing merely the present shops, dwellings, and houses of the depot, as an ordnance reservation, these two strips being connected at one end by a narrow strip bordering on the east wall of Fort Santiago and within the walled city, the general shape of this reservation being that of the letter U. The space separating the side strips is a plaza, which is a sort of debatable ground, being claimed by the city of Manila and held by the United States temporarily and only for military purposes.

The chief ordnance officer has pointed out the great advantage that would ensue from adding to the depot the space embraced within the walls of Fort Santiago, now used mainly for division headquarters offices, and if the division commander should find it desirable to transfer the headquarters offices, it is recommended that the needs of this department receive consideration in the disposition of the space vacated. Attention is drawn later on in this report to the need of further storage facilities, and it is believed that no better site can be found near Manila for an ordnance establishment than the present one, especially if Fort Santiago could be added, since it is situated on the river not far from the mouth, and where but little dredging would be needed to gain the depth of water sufficient for landing and shipping heavy parts.

If the block of buildings belonging to this department, east of the new office building above referred to, should be considered more desirable for headquarters offices than Fort Santiago, an exchange could doubtless be advantageously effected.

Sufficient additional shop room will be needed for installation of a large boring mill, a large planer, and a large lathe, and a few other machines, including a shaper, milling machines, and drill press; and these will have to be placed outside the quadrangle of the present shops, as the space there is already crowded.

STOREHOUSES.

The storage facilities are insufficient for the requirements of the depot. As a result of lack of proper storage room it has been necessary to store certain small arms, ammunition, and other stores in damp casemates in the old stone walls of Manila to make room in the drier storehouses for the more destructible material; to store certain artillery limbers and caissons under the eaves of the small-arms ammunition storehouse, more or less exposed to the weather, while at the present writing ten 7-inch breech-loading siege howitzers and twelve 5-inch breech-loading rifles, together with carriages, limbers, caissons, etc., are left on the plaza of the depot protected only by paulins from the weather.

ISSUE AND RECEIPT OF STORES.

The total weight of stores issued from the Manila Ordnance Depot during the fiscal year amounted to 1,027 tons (long) and the total weight of stores received amounted to 840 tons (long). The number of separate issues amounted to 1,535 and the number of separate receipts amounted to 1,063. One thousand two hundred and ninety-eight requisitions for ordnance and ordnance stores were received during the fiscal year.

STORES SENT TO THE LOUISIANA PURCHASE EXPOSITION AT ST. LOUIS, MO.

On November 25, 1903, the following obsolete ordnance and ordnance stores were turned over to the Philippine Exposition Board for shipment to the Louisiana Purchase Exposition, at St. Louis, Mo.:

1 bronze cannon, 15 centimeter.
1 cannon, 9 centimeter, model 1897.
1 Gonzales Hontoria, 7 centimeter, rifle with mount.
1 Nordenfeldt machine gun, caliber 1-inch, with carriage.
4 Nordenfeldt machine guns.
1 Nordenfeldt machine gun, caliber .301, about.
26 gas-pipe guns.
1 gas-pipe gun with carriage.
138 brass cannon, assorted.
8 iron cannon, assorted.
8 iron cannon, assorted, with carriages.
23 bronze cannon, with carriages.
2 carriages, wooden, various.
20 mortars, saluting.
1 deck platform for 9-centimeter naval gun.
9 carbines, various.
15 rifles, various.
6 gas-pipe shoulder guns.
2 shotguns, various.
2 muskets.
983 revolvers, various.
19 bells.
6 arm chests, revolver, caliber .38.
11 arm chests, rifle, caliber .45.
1,000 rifles, various; total weight, 39,145 pounds.

This property was received at the Manila Ordnance Depot from troops in the field, having been captured from or abandoned by the insurgents. The shipment contained some rare old specimens of workmanship and ingenuity in the manufacture of implements of war.

At the close of the exposition these stores are to be returned to the Ordnance Department at some arsenal in the United States, when they will be listed for sale. Stores condemned at the depot: Notwithstanding every effort is made to prevent sending to the depot worthless, unserviceable stores from the field, it is necessary to condemn a large amount so turned in. During the year 66,978 items were inspected and condemned, representing a money value, when new, of $17,981.96. Only one sale of condemned stores was ordered by the inspector, the stores sold bringing $18.50. The rest of this property was destroyed by the inspector.

OFFICE WORK.

The work done in settlement of property returns of officers at the Manila Ordnance Depot is detailed earlier in this report under the heading of similar work in the Ordnance Office.

Placing the clerical positions in the Ordnance Department in the Philippines under the classified service has done much toward establishing the department here on a more permanent working basis. It has given the clerks a status whereby they have some hope of reward for faithful service by employment in the United States, and it enables the department to retain the services of experienced men.

FUNDS RECEIVED AND DISBURSED.

The account of money received and disbursed under ordnance appropriations during the fiscal year is as follows:

RECEIPTS.		
Received from the Treasury	$60, 854. 06	
Received on account of overpayment	4. 29	
		$60, 858. 35
EXPENDITURES.		
Disbursed during the year	$58, 317. 55	
Outstanding indebtedness, June 30, 1904	1, 390. 74	
To be deposited to credit of Treasurer of United States to cover amounts deducted from salaries of employees to cover cost of transportation, etc., per agreements	571. 94	
To be deposited in Treasury to credit of Treasurer United States under appropriations not available here	60. 00	
Total		60, 340. 23
Unexpended balance		518. 12

One thousand one hundred and forty-five dollars and ninety-four cents was deducted from the total amount allowed this depot for the fiscal year and expended in the United States for material sent from the United States for use in work at this depot. The total amount allotted this depot for the fiscal year was $62,000.

ORDNANCE BOARD.

Membership of the Ordnance Board, June 30, 1904, is as follows:

Lieut. Col. Charles S. Smith, Ordnance Department, U. S. Army.
Lieut. Col. William L. Marshall, Corps of Engineers, U. S. Army.
Maj. R. Birnie, Ordnance Department, U. S. Army.
Maj. George L. Anderson, Artillery Corps, U. S. Army.
Capt. B. W. Dunn, Ordnance Department, U. S. Army.

Maj. M. M. Macomb, Artillery Corps, U. S. Army, was relieved from duty as member of the board by Special Orders, No. 93, War Department, Washington, December 3, 1903.

Maj. William L. Marshall, Corps of Engineers, U. S. Army, was detailed by Special Orders, No. 160, Headquarters of the Army, Adjutant-General's Office, Washington, July 10, 1903, as a member of the Ordnance Board for duty during consideration by the board of matters pertaining to the Engineer Department.

The following is a list of the principal subjects reported upon during the year ended June 30, 1904:

Reference file No.	Subject.	Date of report.	Nature of report.
36292	Ehrhardt 2-inch field gun and carriage.	Sept. 23, 1903	Not recommended. Should it be decided to adopt a lighter equipment than the 3-inch field gun, it should be of a caliber to employ an efficient shrapnel.
25537	37-millimeter Vickers-Maxim 1-pounder automatic gun, with mountain equipment (supplemental test).	Dec. 30, 1903	Recommended for adoption in the movable armament of seacoast defenses.
37977	Type 15-pounder R. F. gun and mount, barbette carriage, model 1902. Bethlehem Steel Co.	Apr. 16, 1904	Test generally satisfactory.
31149 38182 36989	Types of mountain guns for service.	Sept. 29, 1903	Vickers-Maxim 75-millimeter mountain gun, with recommended modifications, deemed sufficiently powerful for the service.
24802	Bofors 6-inch R. F. gun	July 20, 1903 (Board of Ordnance and Fortification).	Satisfactory.
24802	Breech mechanism for 6-inch R. F. guns.	July 24, 1903	Bofors mechanism preferred, as compared with 6-inch Vickers-Maxim and 6-inch model 1900.
11381	Firing mechanisms for 8-inch, 10-inch, and 12-inch B. L. rifles, and 12-inch B. L. mortar.	Jan. 25, 1904	Recommending adoption of Horney firing mechanism, with changes from model of 1903, indicated.
38292	Lining tube for seacoast gun injured by erosion.	Aug. 19, 1903	Plans and computations.
35146	10-inch mortar carriage, model 1900.	Aug. 11, 1903	Test suspended.
30160-F-205	Experimental mechanical rammer with 12-inch disappearing carriage, model 1901, No. 3.	June 23, 1904	Test unsatisfactory in the form of rammer tried. Modifications recommended.
23565-F-110	Safety firing switch for disappearing carriages.	Mar. 26, 1904	Modification recommended.
25241 36940	Loading platforms for disappearing carriages at practice with subcaliber tubes.	July 28, 1903, and Nov. 13, 1903; fourth indorsement on 36940-362.	Recommending design. Amendments.
37198	Illumination of elevation and azimuth scales for seacoast-gun carriages.	Nov. 9, 1903	Recommendations as to number and kind of lights.
36862-27	Triple-worm gear for 12-inch B. L. rifle, model 1900.	Indorsement June 4, 1903.	Recommended.
23565	Temperature tests of smokeless powder.	Feb. 12, 1904; indorsement Mar. 10, 1904.	Tabulated results.
30024-N-59	Specifications for chemical tests and for manufacture of smokeless powders.	Indorsement July 27, 1903.	Revised specifications.
35543	Value of (*c*) for 8 and 12 inch projectiles.	Indorsement Feb. 17, 1904.	Value of (*c*).
38375	Experimental 15-pounder A. P. shell submitted by the Board of Ordnance and Fortification for Mr. Parke Shee.	Oct. 20, 1903	Test unsatisfactory.
38252	Experimental 12-inch "rendible" A. P. shot, Firth-Sterling Steel Co.	Sept. 26, 1903	Do.
38238	15-pounder A. P. steel shell, designed for high explosive charge.	Oct. 9, 1903	Test satisfactory.
23100	3-inch high explosive field shell	Feb. 1, 1904	Recommended for service.
38195	Range firings with 75-millimeter subcaliber tube.	May 14, 1904	Data for range tables.
24493 37438	Comparison of cast-iron projectiles, capped, for 12-inch mortar.	Feb. 2, 1904	Recommended for target practice.
24171	5-inch cast-iron shell with bursting charge in crinoline bag.	Apr. 23, 1904	Not recommended. Test made.
38491	Bethlehem 6-pounder steel shell with ribbed cavity.	June 21, 1904	Recommended provisionally.

Reference file No.	Subject.	Date of report.	Nature of report.
35543	Deck armor with 8, 10, and 12 inch A. P. shell, capped at various angles of incidence.	May 4, 1904	Preliminary report. Test completed except 10 and 12 inch capped and uncapped shell against 3-inch plate.
29020	Test of 4.5-inch armor plates, inclined 45°, with 6-inch rifle.	July 7, 1903	Nickel steel plate recommended.
37811	4.5-inch shield for 6-inch barbette carriage.	July 31, 1903	Trials satisfactory.
37819	Forbes telemeter or range finder, binocular glass and folding base.	Aug. 31, 1903	Recommended for trial at Fort Leavenworth.
37845	Bar sight with 3-inch telescope; Warner & Swasey contract, July 18, 1902.	June 18, 1903; Oct. 6, 1903.	Recommended alterations.
35715	Telescopic bore sight for 8, 10, and 12 inch B. L. rifles.	Nov. 24, 1903	Test unsatisfactory.
37089	Artillery towing targets	Aug. 8, 1903; June 10, 1904.	Design recommended. Report of trials.
30160	Quadrants for 12-inch B. L. mortar.	May 20, 1904	Recommending design of Captain O'Hern.
4513	Scott automatic sight	Sept. 9, 1903	Preliminary report.
4613	Horizontal range finder, Warner & Swasey.	Dec. 23, 1903	Test favorable to its construction.
34852	Stang range finder (Norway)	Dec. 22, 1903	Purchase of sample instrument recommended.
36020 37848	Clarke automatic sight, 4.7-inch barbette carriage at Fort Wadsworth. 3-inch objective telescopic sights, Warner & Swasey. For tests of substitution of Poro prisms in model 1904.	Indorsement May 4, 1904.	Recommending the Poro prisms.
25537	Grubb sight	Indorsement Mar. 29, 1904.	Does not compare favorably with other telescopes.
38513	H. L. Rodgers, Boston, Mass., range finder.	Indorsement Jan. 16, 1904.	Jan. 16, 1904. Not recommended.
38431	Evans, Wilkins & Co., Washington, Stewart range finder.	Oct. 30, 1903	Not recommended.
38357	Thompson mechanical time fuze	Indorsement June 27, 1904.	Test unsatisfactory.
38651	Hacherelle mechanical time fuze	do	Purchase of sample lot of 30 recommended.
38602	Wilson-Lynch eccentric percussion fuze, United States Ordnance Company.	Indorsement Apr. 27, 1904.	Trial unsatisfactory.
37494	Jos. C. Heulings: Loeben Cannon patents.	Oct. 13, 1903	Not considered practical and effective.
38385	Elliotite explosive, J. P. Elliott, Washington, D. C.	Indorsement Dec. 8, 1903.	Not satisfactory.
36329	E. F. Houghton & Co., Philadelphia, Pa., vici leather packing.	Jan. 9, 1904	Recommended.
38641	Motley Green & Co., New York	Megadyne explosive.	Sample found too sensitive in impact test.

The following papers are submitted as appendices to this report:

Appendix I.—Report of board on test of automatic machine guns. (15 plates.)

Appendix II.—Resistance offered by cupro-nickel bullets when forced through bore of caliber .30 barrel. (8 plates.)

Appendix III.—Test of different widths of tires with siege artillery carriages. (23 plates.)

Appendix IV.—Report from chemical laboratory at Sandy Hook Proving Ground. (19 plates.)

Appendix V.—Report of Ordnance Board on range firings with 12-inch mortars. (3 plates.)

Appendix VI.—Report of Ordnance Board on test of field material. (23 plates.)

Very respectfully,

WILLIAM CROZIER,
Brig. Gen., Chief of Ordnance.

The SECRETARY OF WAR.

APPENDIX I.

REPORT OF BOARD ON TEST OF AUTOMATIC MACHINE GUNS.

(15 plates.)

Proceedings of a board of officers convened by the following order:

Special Orders, No. 169.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, July 21, 1903.

[Extract.]

* * * * * * *

36. By direction of the Secretary of War a board of officers will assemble at Springfield Armory, Springfield, Mass., on Monday, August 10, 1903, at 10 o'clock a. m., or as soon thereafter as practicable, for the purpose of testing such automatic machine guns, mounts, and pack outfits as may be referred to it by the Chief of Ordnance.

Detail for the board:

Capt. Edwin V. Bookmiller, Ninth Infantry.
Capt. Tracy C. Dickson, Ordnance Department.
Capt. John S. Winn, Second Cavalry.
Capt. George D. Guyer, Sixteenth Infantry.
Capt. William S. McNair, Artillery Corps.

Captain Dickson will act as recorder of the board.

The following-named enlisted men will proceed to Springfield Armory, Springfield, Mass., and report in person to the senior member of the board on August 10, 1903, for duty with the board:

Sergt. John Mulligan, Troop K, Second Cavalry.
Sergt. Don L. Monteith, Troop I, Second Cavalry.
Corpl. Joseph Thwaites, Twenty-third Battery, Field Artillery.
Sergt. John J. McCarthy, Company A, Ninth Infantry.
Corpl. David Costello, Company D, Ninth Infantry.

A programme of tests will be drawn up by the board and a copy thereof furnished the Chief of Ordnance. The board will conduct all tests relating to the safety and action of the mechanisms, the endurance and strength of the systems, and the accuracy and rapidity of fire at the Springfield Armory. Upon the completion of this part of the tests the board, accompanied by the above-named enlisted men, will proceed to Fort Riley, Kans., and there conclude the programme with the tests of the mounts and pack outfits.

The commanding officer of Springfield Armory and of Fort Riley, Kans., will afford all assistance and facilities required by the board in carrying out the programme adopted.

The programme of tests will be drawn up, the trial conducted and expedited in the most practicable manner for the purpose of ascertaining the following, viz:

First. The design of automatic machine gun best adapted to fulfill the requirements of the military service.

Second. The design of mount and pack outfit best adapted for field service.

Third. The most convenient and serviceable form in which ammunition for automatic machine guns should be packed and issued.

Fourth. The number of rounds of ammunition for which pack transportation should be provided with each gun.

Upon the completion of the programme the board will submit a report of the tests with recommendations to the Chief of Ordnance, and upon its adjournment the members and the enlisted men will return to their proper stations.

The enlisted men upon the detachment will be paid commutation of rations in advance at the rate of $1.50 per day while en route to the points requiring their presence in this order, it being impracticable for them to carry rations in kind.

The travel enjoined is necessary for the public service.

By command of Lieutenant-General Miles:

W. P. Hall,
Acting Adjutant-General.

The convening order was subsequently amended by a letter addressed to each member of the board and by the following order:

War Department,
Adjutant-General's Office,
Washington, July 31, 1903.

Sir: Referring to paragraph 36, Special Orders, No. 169, July 21, 1903, from this office, convening a board of officers to meet at Springfield Armory, Springfield, Mass., on August 10, 1903, for the purpose of testing automatic machine guns, etc., I have the honor to inform you that the Secretary of War so modifies the order above cited as to direct that the board shall meet at the Springfield Armory on August 20, 1903.

Very respectfully,

Jas. S. Pettit,
Assistant Adjutant-General.

Special Orders, No. 21.

War Department,
Washington, September 9, 1903.

[Extract.]

* * * * * * *

23. Paragraph 36, Special Orders, No. 169, July 21, 1903, Adjutant-General's Office, is so amended as to direct the members of the board convened by said order and the enlisted men on duty therewith, upon the completion of the firing tests at the Springfield Armory, Springfield Mass., to proceed to Fort Riley, Kans., for the purpose of making the tests of the mounts, pack outfits, carriages, etc., prior to the army maneuvers to be held at that place, and upon the completion of the tests to return to the Springfield Armory and there conclude the programme of tests outlined in the order above cited, and upon the adjournment of the board the officers and enlisted men to return to their proper stations. The enlisted men upon the detachment will be paid commutation of rations in advance at the rate of $1.50 per day while en route to the points requiring their presence in this order, it being impracticable for them to carry rations in kind. The travel enjoined is necessary for the public service.

* * * * * * *

By order of the Secretary of War:

S. B. M. Young,
Lieutenant-General, Chief of Staff.

Official:
W. P. Hall,
Acting Adjutant-General:

Springfield Armory,
Springfield, Mass., October 18, 1903.

The board met pursuant to the foregoing orders at 10 a. m., August 20, 1903, with all the members present. The enlisted men named in the convening order reported in person to the senior member and remained on duty with the board until its adjournment.

The board proceeded with the tests of the material submitted to it, meeting from day to day with all members present except as follows, viz: Capt. T. C. Dickson, Ordnance Department, absent on official business as recorder of the Board of Ordnance and Fortification from September 1 to 12, inclusive, and from September 28 to October 2, inclusive. Capt. George D. Guyer, Sixteenth Infantry, absent on official business as witness before a general court-martial from September 15 to 18, inclusive, pursuant to telegraphic instructions from the Adjutant-General, United States Army.

A programme of tests was adopted and a copy thereof submitted to the Chief of Ordnance, United States Army, which was approved by him.

The commanding officer of Springfield Armory, in accordance with the instructions of the Chief of Ordnance, turned over to the board, upon its convening, the following automatic machine guns, mounts, pack outfits, etc., viz:

Danish rifle-mitrailleuse, tripod, loading machine, and accessories.

Colt's automatic machine gun, tripod, and mount, carriage, loading machine, and accessories. The pack outfit for this gun was delivered to the board at Fort Riley, Kans.

On September 14 the Vickers Sons & Maxim solid action and standard pattern automatic machine guns, combined field carriage and tripod, galloping carriage with sleigh mounting, pack outfit, loading machine and accessories were delivered to the board.

On October 13 the Vickers Sons & Maxim light tripod was delivered to the board.

In accordance with paragraph 23 of Special Orders, No. 21, War Department, September 9, 1903, the board, having completed nearly all the firing tests of the Danish, Colt, and two Vickers guns, proceeded to Fort Riley, Kans., and there conducted the field tests from September 28 until October 6, 1903, when it returned to the Springfield Armory.

Except where otherwise stated in the proceedings, all tests and firings were made by the members of the board, assisted by the enlisted men.

On account of inclement weather, etc., the tests were not all made in the order given in the programme. The total number of rounds given at the completion of each test indicates the order in which the tests made with each gun were conducted.

All ammunition fired in the Colt and two Vickers guns was marked "Rifle velocity at 53 feet, 2,255 feet."

An illustrated description of all the material furnished the board for test is appended hereto.

PROGRAMME OF TESTS OF AUTOMATIC MACHINE GUNS.

Each of the tests that include firing at a target will be preceded by as many sighting shots as may be necessary to insure accuracy of aim, and the number of shots so fired in each case will be recorded. Should the design of any gun be of such a nature as to require additional or further tests to determine its suitability for the military service, such tests will be made, and the reasons therefor and the results obtained stated.

PART I.

Test 1.

(*a*) The gun will be dismounted and an examination made by the board of all the working parts of the gun, feed mechanism, loading machine, etc.

(*b*) The number of working parts, screws, and springs will be recorded.

(*c*) The chamber will be gauged and the headspace measured; the length of the bolt, and of all shoulders and lugs which sustain the powder pressure will be recorded.

Test 2.

One hundred shots will be fired deliberately into a stop butt to determine the action of the gun.

Test 3.

The velocity at 53 feet from the muzzle will be measured. This velocity will be the mean of ten consecutive shots.

Test 4.

(*a*) A belt of 100 cartridges in which every fifth one is a dummy, and in which 15 of the ball cartridges have been removed at irregular intervals in order to determine the effect of blank spaces, will be run through the gun and the ball cartridges fired into a stop butt.

(*b*) Twenty-five cartridges will be fired into a stop butt, the bullets in three of the cartridges being seated about one-quarter of an inch too deep in the case, the bullets of three other cartridges projecting about one-quarter of an inch too far from the case, and five of the cases being deformed by flattening the body different amounts.

Test 5.

Replacing parts damaged or broken while firing.

(*a*) Removing and reinserting lock.

(*b*) Removing and reinserting the extractor.

(*c*) Removing and reinserting the firing pin.

(*d*) Removing and reinserting any other parts of the breech mechanism which from their design are liable to be injured in action.

In making tests (*a*), (*b*), (*c*), and (*d*) the accident is supposed to happen during firing and while the feed belt is partially full. The time elapsing between the order to replace the part and the recommencement of firing will be recorded in each case.

Test 6.

(*a*) Twenty-five shots will be fired into a stop butt, the cartridge cases of three of which were previously thoroughly coated with resin to determine the effect of a cartridge stuck in the chamber.

(*b*) The extractor will be removed and an attempt made to fire five cartridges from the belt to test the effect of a broken extractor.

Test 7.

(*a*) Two hundred shots will be fired to test the action of the feed mechanism with the gun at the greatest depression obtainable. The angle of depression, time of firing 200 shots, action of feed, and effect of recoil on mount and aim will be noted.

(*b*) Two hundred shots will be fired to test the action of the feed mechanism with the gun at the greatest elevation obtainable. The angle of elevation, time of firing the 200 shots, action of feed, and effect of recoil on mount and aim will be noted.

(*c*) Two hundred shots will be fired to test the action of the feed mechanism with the gun kept constantly in motion between greatest depression and highest elevation obtainable. The angle of variation, time of firing 200 shots, action of feed, and effect of recoil on the mount and aim will be noted.

Test 8.

Two hundred shots will be fired automatically with the normal rapidity of the gun at a target 12 feet by 30 feet at 500 yards' range with the aim fixed. Hits, time, action of gun, derangement of aim, and dispersion of hits on target will be noted.

Test 9.

Two hundred shots will be fired automatically with the extreme rapidity obtainable at a target 12 feet by 30 feet at 500 yards' range, with the aim fixed. Hits, time, action of gun, derangement of aim, and dispersion of hits on target will be noted.

Test 10.

Two hundred shots will be fired automatically with the normal rapidity of the gun at a target 12 feet by 45 feet at 500 yards' range, aim oscillating. Hits, time, and action of gun will be noted.

Test 11.

Two hundred shots will be fired automatically with the normal rapidity of gun at a target 12 feet by 30 feet at 1,000 yards' range, aim fixed. Hits, time, action of gun, derangement of aim, and dispersion of shots on target will be noted.

Test 12.

Two hundred shots will be fired automatically with the extreme rapidity obtainable with the gun at a target 12 feet by 30 feet, at 1,000 yards' range, aim fixed. Hits, time, action of gun, derangement of aim and dispersion of shots on target will be noted.

Test 13.

The following series of consecutive rounds will be fired automatically at a target 12 by 30 feet, at some convenient range, in order to determine the endurance of the gun; effect of the heat developed upon the working of the mechanism; the rate of firing to be the normal of the particular gun under test, aim fixed:

First series, 1,000 rounds.
Second series, 2,000 rounds.
Third series, 3,000 rounds.

Fourth series, continuous firing to determine the number of rounds that can be fired without interruption before the action of the gun is impaired by heat, fouling, etc.; the number of rounds fired to be recorded.

For each of the above series the number and dispersion of hits, time and action of gun and mount will be recorded. The condition of the mechanism before commencing and at the end of each series will be recorded.

If the barrel is cooled with water, the rate of evaporation for each series will be recorded.

As soon as the last shot of each of the above four series has been fired a cartridge will be inserted in the chamber and the breech mechanism closed in order to determine the effect upon the mechanism in case the cartridge should be fired by the remaining heat.

Test 14.

The gun will be cleaned and dismounted and all the working parts of the mechanism examined and any changes therein noted. The chamber will be gauged. The headspace and such other parts as were measured under Test 1 will be remeasured and the changes tabulated.

Test 15.

To test the action of the mechanism with increased and reduced powder pressure 25 consecutive shots will be fired with cartridges loaded to give a powder pressure 25 per cent greater than the standard, and 25 loaded to give a powder pressure 25 per cent less than the standard; action of mechanism to be noted.

Test 16.

The gun will be fired twice with each of the following cartridges:

(*a*) Cross-filed on head to nearly the thickness of metal.
(*b*) Cut at intervals through extractor groove into powder space.
(*c*) Cut longitudinally nearly through body of shell.

Test 17.

The gun to be dismounted, thoroughly cleaned, and all parts dried before assembling, after which it will be exposed, with mechanism closed and both ends of barrel tightly corked, to a blast of fine sand for fifteen seconds; surplus sand to be removed by blowing thereon and wiping with bare hand; 100 shots will then be fired into a stop-butt; time of firing 100 shots and action of gun to be noted.

Test 18.

Five cartridges loaded to give a powder pressure of 75,000 pounds per square inch will be fired to test the strength of the working parts. The mechanism will then be examined, the chamber gauged, the headspace and other parts measured, and all changes tabulated.

Test 19.

The gun will be dismounted, all parts thoroughly cleaned and dried, and, after assembling, the ends of the barrel will be tightly corked, and the gun then placed in a saturated solution of sal ammoniac for 5 minutes. After exposure in a damp atmosphere for 48 hours 100 shots will be fired into a stop butt. Time of firing and action of the gun will be recorded.

Test 20.

(*a*) Time required to load 1,000 cartridges into belt or feed-guide, both by machine and by hand.

(*b*) Two belts or feed-guides filled with cartridges will be soaked in water for 12 hours. At the end of this time one belt or feed-guide will be handled as roughly as is liable to occur under service conditions and the cartridges then fired; the second belt or feed-guide will be exposed to the air until dry, then handled as roughly as is liable to occur under service conditions and the cartridges fired.

(*c*) Six belts or feed-guides will be soaked in water for 12 hours. One belt or feed-guide will then be loaded by machine and the cartridges fired; a second will be loaded by machine, then dried by exposure to the air and the cartridges fired; a third will be dried by exposure to the air and then loaded by machine and the cartridges fired; a fourth will be loaded by hand and the cartridges fired; a fifth will be loaded by hand, then dried by exposure to the air and the cartridges fired, and a sixth will be dried by exposure to the air, then loaded by hand, and the cartridges fired.

PART II.

MOUNTS, PACK OUTFITS, AND CARRIAGES.

Test 1.

A general examination of the packs, mounts, and carriages will be made by the board.

Test 2.

A detachment will be formed and thoroughly drilled in packing and handling each gun and its mount.

Test 3.

Being on the march, the time required to unpack each gun, mount, and 500 rounds of ammunition and to bring them into action and commence firing will be determined.

Test 4.

When firing, the time required to pack each gun, mount, and ammunition, and to take up the march will be determined.

Test 5.

Being on the march, the time required for each detachment of 3 men to unpack the gun, tripod or mount, and 500 rounds of ammunition, and to carry them forward on the run 300 yards, and to set them up and begin firing will be determined. This test will be repeated with the Vickers combined carriage and tripod, 2 men running the carriage with the gun mounted thereon and 1 man carrying 500 rounds of ammunition forward over the same ground.

Test 6.

The galloping carriage with the Vickers Sons & Maxim gun will accompany the pack train on its marches; it will be drawn by a single horse on the 9-mile and by 2 horses on the other marches. All tests prescribed for the pack outfit, when applicable, will be made with this carriage and the sleigh mount.

Test 7.

A march of about 9 miles will be made, the gait to be that of cavalry marching at a walk.

Test 8.

A march of about 15 miles will be made, the gait to be at a trot for about one-half the distance.

Test 9.

On three consecutive days marches of about 20 miles each will be made, one-half the distance each day to be at a trot, if practicable.

Test 10.

The following points will be determined by actual drill with the pack oufit recommended for adoption, viz:

(*a*) The number of pack mules required for the pack outfit for one gun with its mount, ammunition, loading machine, spare parts, accessories, water, etc.

(*b*) The articles that should be packed on each mule.

(*c*) The number of men of which a detachment should consist for properly handling the pack outfit for one gun, mount, ammunition, etc.

(*d*) The total number of rounds of ammunition that should be carried with one gun.

(*e*) The best method of carrying the ammunition.

(*f*) The amount of water that should be carried with one gun provided with water jacket and the best method for transporting it.

RESULTS OF PROGRAMME OF TESTS OF DANISH RIFLE MITRAILLEUSE.

Lieut. Jens Stouboe, of the Danish army, the inventor of this gun, was present during its test. The caliber of the gun submitted to the board was 6.5 millimeters, and therefore the United States standard cartridge could not be used in it. Owing to the limited number of rounds of 6.5-millimeter ammunition furnished with the gun, the number to be fired under each test was proportionately reduced. The ammunition furnished with the gun was marked "6.5 mm. of 1899."

Test 1.

(*a*) The gun was completely dismounted and all parts examined by the members of the board.

(*b*) This gun is composed of 80 component parts, exclusive of the front and rear sights and of the tripod arms attached to the barrel casing. Included in these 80 parts are 11 spiral springs, 1 flat spring, 15 pins, and 9 screws. The screws have spring arms instead of slotted heads.

(*c*) The interior dimensions of the chamber, the head space, the length of the bolt, and the distance from the rear end of the barrel to the rear support of the breechblock in the receiver were measured.

Test 2.

Thirty rounds were fired automatically into a stop butt to determine the action of the gun, which was excellent. Time, 4 seconds.

Total number of rounds fired, 30.

Test 3.

The velocity at 53 feet from the muzzle was measured and found to be 2,228 feet per second.

Total number of rounds fired, 54.

Test 4.

(*a*) A feed case loaded with 20 ball and 5 dummy cartridges, every fifth being a dummy, was inserted in the hopper and the 20 ball cartridges fired. Time of firing, 18 seconds. When the gun was snapped on a dummy it was necessary to pull the crank back once in order to eject the dummy and insert the next cartridge in the chamber, when firing could be resumed by pulling the trigger. The design of this feed case is such that empty spaces can not occur in it.

Total number of rounds fired, 74.

(*b*) One feed case was loaded with 25 cartridges, which were fired in the following order, viz: 5 ball cartridges, 1 ball cartridge with the body of case markedly flattened, 1 ball cartridge, 1 ball cartridge with body of case slightly dented, 1 ball cartridge, 1 ball cartridge with body of case slightly flattened, 1 ball cartridge, 1 ball cartridge slightly dented at the neck, 1 ball cartridge, 1 ball cartridge dented longitudinally in the body, 1 ball cartridge, 3 ball cartridges with the bullets withdrawn one thirty-second of an inch from the case, 1 ball cartridge, 1 ball cartridge with the bullet inserted one-fourth of an inch in the case farther than in the standard cartridge, 1 ball cartridge, 1 ball cartridge with the bullet inserted one-fourth of an inch, 1 ball cartridge, 1 ball cartridge with the bullet inserted one-fourth of an inch, 1 ball cartridge. The first cartridge with the flattened case could not be fully inserted in the chamber and it was necessary to take the gun apart in order to remove it; the second dented cartridge was not fully seated in the chamber, but was extracted by means of the crank; the third flattened cartridge was inserted and fired; the fourth could not be inserted in the chamber and had to be removed, and the fifth was fired and extracted automatically. As the barrel of this gun was rifled so that the bullet bears on the rear end of the rifling when the cartridge is properly seated in the chamber, the three cartridges with bullets projecting one thirty-second of an inch too much from the case could not be forced into the chamber and were not fired. The remainder of the cartridges in the feed case were satisfactorily fired.

Total number of rounds fired, 93.

Test 5.

The replacing of the parts was done by the same member of the board that made this test with all the guns tested. The time recorded in each case was that elapsing from the signal to cease firing until firing was resumed.

(*a*) Time required to remove and reinsert the lock, 3 minutes and 13 seconds.

(*b*) Time required to remove and reinsert the extractor, 1 minute and 38 seconds.

(*c*) Time required to remove and reinsert the firing pin, 3 minutes and 25 seconds.

(*d*) No additional parts were removed.

Total number of rounds fired, 147.

Test 6.

(*a*) Three cartridge cases were thoroughly coated with resin and loaded with 22 other cartridges into a feed case, and fired satisfactorily.

Total number of rounds fired, 172.

(*b*) The design of the gun being such that with a broken extractor the cartridge case could not be removed from the chamber, this test was omitted.

Test 7.

(*a*), (*b*), (*c*). As this gun is in reality a magazine rifle with an exterior magazine, and as the feed of the cartridges from the feed case into the hopper is positive at all elevations, this test was omitted.

Test 8.

First trial.—Five sighting shots were fired. After firing 20 rounds the barrel and receiver did not recoil sufficiently far to cause the cartridge feeder to engage the cartridge in the hopper. At the board's request, Lieutenant Stouboe replaced the percussion spring by a weaker one. When this was done the cam on the percussion lever was found to be burred.

Total number of rounds fired, 118.

Second trial.—Four sighting shots were fired. In attempting to fire 200 rounds the recoil of the barrel was still not sufficient to properly operate the mechanism after the second, fifth, seventh, ninth, eleventh, and thirteenth shots. A second feed case was inserted, but the mechanism failed on the first shot. The gun and mount were then removed from the ground to a platform floor, but the mechanism failed to operate after the first shot.

Total number of rounds fired, 193. Of the 21 cartridges fired the cases of 7 were found to be split at the neck.

Third trial.—One hundred and eighty rounds were fired with frequent and constant interruptions, due to the failure of the barrel and receiver to recoil sufficiently far to enable the cartridge feeder to engage the lower cartridge in the hopper.

Total number of rounds fired, 373.

In order to increase the energy of recoil of the barrel and receiver, the diameter of the hole in the barrel-casing plug, through which the bullet passes, was decreased so as to increase the reaction of the powder gases against the muzzle of the barrel. After this alteration 100 rounds were fired, during which the recoil was insufficient three times; 150 rounds were then fired with only one insufficient recoil.

Total number of rounds fired, 623.

At the request of Lieutenant Stouboe the cartridges in each feed case were hereafter oiled, as he stated that the parts were now adjusted so that the energy of recoil was too great, and that, therefore, the extractor was liable to be broken. As he had but one extractor for the gun, oiling of the cartridges was permitted.

Fourth trial.—Five sighting shots. After firing about 60 rounds a cartridge was jammed during its passage from the hopper into the chamber, but was removed in a few seconds and firing resumed; 157 rounds were fired satisfactorily, but at the next shot the cartridge case ruptured about one-fourth of an inch in rear of the neck. The latter part remained in chamber and prevented the insertion of the next cartridge; 74 hits on target; 18 cartridge shells were found cracked at the neck.

Total number of rounds fired, 786.

The other members of the board then fired 30 rounds each, with the gun mounted on the tripod, as in the preceding trials, the results of which are recorded in the 5th, 6th, 7th, and 8th trials. Each 30 rounds were fired automatically and without stopping.

Fifth trial.—After 2 sighting shots, 30 rounds were fired with 21 hits. The horizontal distance between extreme shots was 20 feet and the vertical distance 6 feet.

Sixth trial.—After 2 sighting shots, 30 rounds were fired in 4 seconds with 12 hits; 6 cartridge shells were found split at the neck.

Seventh trial.—After 2 sighting shots, 30 rounds were fired in 4⅜ seconds with 26 hits; 4 cartridge shells were found split at the neck.

Eighth trial.—After 2 sighting shots, 30 rounds were fired in 8 seconds with 19 hits; 6 cartridge shells were found split at the neck.

Total number of rounds fired, 914.

The 9th to 15th trials, inclusive, were fired by the members of the board using the prone position and the muzzle-rest device. In these trials particular attention was paid to keeping the gun accurately aimed and, when necessary, firing was stopped for that purpose during each lot of 30.

Ninth trial.—After one sighting shot, 7 rounds were fired, when the extractor failed to remove the shell from the chamber.

Tenth trial.—Thirty rounds were fired in 1 minute and 10 seconds, the greater part of which were fired automatically. The recoil was insufficient 3 times to enable the cartridge feeder to catch the cartridge in the hopper; 25 hits; 4 cartridge cases split at the neck.

Eleventh trial.—After one sighting shot, 30 rounds were fired in 1 minute and 8 seconds, most of which were fired automatically; 16 hits. One failure to load.

Twelfth trial.—One sighting shot. First shot failed to properly feed into the chamber, and on the third shot firing was stopped by a cartridge case having ruptured, part of which remained in the chamber.

Thirteenth trial.—Thirty rounds were fired in 1 minute and 6 seconds, 22 as single shots and 8 automatically; 30 hits.

Fourteenth trial.—After one sighting shot, 30 rounds were fired in 55 seconds, 27 as single shots and 3 automatically; 29 hits.

Fifteenth trial.—After one sighting shot, 30 rounds were fired in 55 seconds, with 2 failures to load. These 30 shots were fired automatically in series of 2 each; 25 hits.

Total number of rounds fired, 1,079.

At the request of the board Lieutenant Stouboe fired the 16th and 17th trials, using the prone position.

Sixteenth trial.—One sighting shot was fired. In inserting this cartridge it jammed during its passage into the chamber. Thirty rounds were fired as single shots, with 30 hits. The first 29 were fired in 12 seconds.

Seventeenth trial.—Thirty rounds were fired automatically in 3 seconds, with 22 hits.

Total number of rounds fired, 1,140.

Test 9.

Omitted, since the gun is designed to have but one rate of automatic fire.

Tests 10, 11, and 12.

Omitted, as the feed mechanism of the gun was so uncertain in its action that the results obtained would not be comparable with those obtained with the other guns tested.

Test 13.

On account of the failure of the feed mechanism to operate properly, the board requested Lieutenant Stouboe to make all the firings of this test. The gun was fired from the prone position, using the muzzle rest device.

Before beginning this test both bearings of the barrel were oiled and two sighting shots fired. Ten feed cases were filled, making 300 rounds. The cartridges in the feed cases were oiled. After the 121st shot was fired, the feed mechanism failed to operate. After firing the 122d shot it was found that a shell had ruptured, part remaining in the chamber. Time of firing 122 shots, 1 minute and 10 seconds. The feed mechanism failed to operate at the 124th shot. In inserting the 5th case, 2 cartridges dropped out, and during the firing of that case 1 cartridge jammed in the feed mechanism in such a way as to necessitate partial dismounting of the gun to remove it. The time consumed in dismounting and reassembling these parts was 45 seconds. The 6th and 8th cases were fired without a hitch; one failure of the feed mechanism occurred in the 7th, and during the 9th case firing stopped because the barrel had expanded by the heat until it bound in its rear bearing; 245 cartridges were fed into the hopper, 13 of which were taken out while removing jams and dismounting the gun, making a total of 232 rounds fired in 8¼ minutes, with 151 hits; 4 cartridge cases were ruptured and 64 were split at the neck. Total number of rounds fired, 1,374.

Second trial.—All working parts of the gun were thoroughly oiled. Ten feed cases were loaded with 300 cartridges, which were oiled.

First case: Fired without a jam.

Second case: When case was inserted, the first cartridge jammed in the feed mechanism; firing satisfactory.

Third case: When case was inserted, first cartridge jammed in the feed mechanism.

Fourth case: When case was inserted, the crank had to be operated several times before the first cartridge was inserted in the chamber.

Fifth case: When case was inserted, the first cartridge jammed in the feed mechanism. During the firing of this case the feed mechanism jammed once, and considerable effort was required to remove the cartridge.

Sixth case: Fired without a jam.

Seventh case: When case was inserted, the first cartridge jammed in feed mechanism.

Eighth case: When case was inserted, the first cartridge jammed in feed mechanism and there were three other stops during the firing, due to the same cause. During the firing of this case the elevation changed.

Ninth case: Fired without a jam.

Tenth case: Fired without a jam.

Two hundred and ninety-nine rounds were fired in 5 minutes and 2 seconds, with 252 hits. The horizontal distance between extreme hits was 30 feet and the vertical 15 feet.

When each of the last 6 feed cases were inserted the barrel bound in its rear bearing and the mechanism failed to close automatically. In closing the mechanism by means of the operating handle the operator found it necessary to rise on his knees in order to exert the force required. At the conclusion of this test the ground around the muzzle and beneath the opening in the receiver, through which the empty shells are ejected, was markedly burned.

Total number of rounds fired, 1,673.

As the feed mechanism of this gun constantly failed to operate properly the board deemed it unnecessary to subject it to the remaining tests of the programme.

RESULTS OF THE PROGRAMME OF TESTS WITH COLT AUTOMATIC MACHINE GUN.

Mr. Moore, the representative of the Colt's Patent Fire Arms Manufacturing Company, was present during the tests of this gun.

The Colt's Patent Fire Arms Manufacturing Company informed the board that the barrel rifled with a twist of one turn in 10 inches had been fired 1,125 rounds, and the one rifled with one turn in 8 inches had been fired 90 rounds prior to the submission of their gun to the board. The barrel rifled with one turn in 10 inches was used in the following tests, except where otherwise stated:

Test 1.

(*a*) The gun was completely dismounted and all of its working parts examined by the members of the board.

(*b*) The total number of component parts in this gun, exclusive of the sights, is 100. This includes 14 spiral springs, 18 pins, and 17 screws.

(*c*) The interior dimensions of the chamber, the headspace, and length of the bolt were measured.

Test 2.

One hundred rounds were fired automatically to test the action of the gun, which was excellent.

Total number of rounds fired, 100.

Test 3.

The velocity at 53 feet from the muzzle was found to be 2,277 feet per second; the ammunition used was marked "Rifle velocity at 53 feet 2,255 feet."

Total number of rounds fired, 112.

Test 4.

(*a*) Eighty ball and 20 dummy cartridges were loaded into a belt, every fifth being a dummy. The 8th, 19th, 27th, 28th, 31st, 46th, 47th, 52d, 59th, 67th, 68th, 76th, 82d, 88th, and 99th ball cartridges were removed. The belt was run through the gun in 40 seconds. Each blank space and dummy stopped the firing. When firing was stopped by a dummy or blank space it was necessary to make one oscillation with the gas lever and to pull the feed belt until the next cartridge was engaged by the feed wheel.

Total number of rounds fired, 177.

(*b*) Twenty-five cartridges were loaded into a belt so as to be fired in the following order, viz: 5 ball cartridges, 1 ball cartridge with the case slightly flattened, 1 ball cartridge, 1 ball cartridge with the case dented, 1 ball cartridge, 1 ball cartridge with the case flattened at the neck, 1 ball cartridge, 1 ball cartridge with the body of the case flattened, 1 ball cartridge, 1 ball cartridge with the case dented longitudinally, 1 ball cartridge, 3 ball cartridges with the bullet pulled out of the case one-fourth of an inch farther than in the standard cartridge, 1 ball cartridge, 1 ball cartridge with the bullet inserted one-fourth of an inch in the case farther than in the standard cartridge, 1 ball cartridge, 1 ball cartridge with the bullet inserted one fourth of an inch in the case, 1 ball cartridge, 1 ball cartridge with the bullet inserted one-fourth of an inch in the case, 1 ball cartridge. These cartridges were fired without interruption except that one, with the case flattened, was not automatically seated in the chamber, but was forced in by hand and fired, and the first cartridge with the bullet pulled out one-fourth of an inch could not enter the slots in the side plates, being too long. The bullets of these cartridges were forced into the case so as to project only one-eighth of an inch more than the standard cartridge and were fired without interruption.

Total number of rounds fired, 202.

Test 5.

The replacing of damaged or broken parts was done by the same member of the board who made these tests with all the guns. The time recorded in each case is that elapsing from the signal to stop firing until firing was renewed.

(*a*) The lock was removed and reinserted in 33 seconds.

(*b*) The extractor was removed and reinserted in 1 minute and 31 seconds.

(*c*) The firing pin was removed and reinserted in 1 minute and 32 seconds.

(*d*) No other parts of the breech mechanism were removed.

Total number of rounds fired, 650.

Test 6.

(*a*) Three cartridges were coated with resin, and, as they could be inserted in the belt only with considerable difficulty, were not fired from it. The 3 cartridges were fired and the cases extracted from the chamber and ejected from the gun.

Total number of rounds fired, 653.

(*b*) The first cartridge was fired, but not extracted. The belt was pulled back and the shell removed by a rod inserted in the bore. When the second cartridge was fired the same action occurred.

Total number of rounds fired, 1,298.

Test 7.

(*a*) One sighting shot was fired. The depression of the gun before firing was 33 degrees and 45 minutes. The first 100 rounds were fired with the belt resting on the platform from which the gun was fired, but the bullets caught on the side plates of the gun and the feed mechanism did not work properly. The second 100, with the belt in the box, were fired without a hitch in 12 seconds. After firing 200 rounds the depression was 32 degrees and 40 minutes. This test was made with the gun on a wooden platform, and at its conclusion the mount had moved to the rear about one-half an inch.

(*b*) Angle of elevation, 34 degrees and 50 minutes; 200 rounds were fired in 24 seconds. Action of gun excellent; no change in elevation occurred.

(*c*) Two hundred rounds were fired with the aim oscillating between a depression of 33 degrees and 45 minutes and an elevation of 34 degrees and 50 minutes in 26⅕ seconds. Action of gun excellent.

Total number of rounds fired, 2,261.

Special test.

In order to further test the action of the feed mechanism with the belt resting on the platform on which the mount was placed, with aim oscillating between an angle of 15° depression and 15° elevation, 41 rounds were fired with the aim constantly changing between these limits, when the firing was stopped by the extractor failing to remove an empty shell from the chamber. The bullet in the cartridge on the carrier was pushed in against the powder. The feed mechanism worked satisfactorily.

Total number of rounds fired, 2,302.

Test 8.

Eight sighting shots were fired. At the 113th round firing was stopped by an apparent misfire; time of firing 113 rounds, 14⅗ seconds. At the 135th round firing was stopped by an apparent misfire; time of firing the 135 rounds, 18⅗ seconds. At the 180th round firing was stopped by an apparent misfire; time of firing 180 rounds, 25⅖ seconds. The 200 rounds were fired in 29 seconds. During this firing the elevation changed slightly, the muzzle having worked upward; 152 hits. The horizontal distance between extreme shots was 5½ feet and the vertical distance 6 feet.

Second trial.—Before beginning this series a longer firing pin was inserted and one sighting shot fired; 200 rounds were fired in 24⅗ seconds, all of which struck the target. The horizontal distance between extreme shots was 5 feet 11 inches and the vertical distance 6 feet 11 inches. Six of the shots were relatively low and to the right of the remainder, most of which were closely grouped. Four cartridge shells, split at the neck, and one leaky primer were found. The 3 cartridges that misfired in the first trial were then inserted and fired, showing that the apparent misfires in that series were due to a defective firing pin.

Total number of rounds fired, 611.

Test 9.

As this gun is constructed to have but one rate of automatic fire, this test was omitted.

Test 10.

Before beginning this test a clamping device designed by the company for its mount was attached and the clamp adjusted so that the oscillation of the gun was limited within the angle subtending the target. Four sighting shots were fired; 200 rounds were fired in 24 seconds. As the clamp for limiting the oscillation of the gun worked loose, a large number of shots struck to the right and left of the target. One leaky primer was found. Sixteen shots were then fired by the different members of the board for the purpose of familiarizing themselves with the oscillation of the mount when firing automatically.

Second trial.—Two hundred shots were fired; time lost, 110 hits. During the firing it was necessary to decrease the elevation, which gradually increased. One cartridge, which was not fired, and the primer of which indicated that it had been struck only a light blow, was inserted in the gun and on second trial fired.

Total number of rounds fired, 1,073.

Test 11.

First trial.—Seven sighting shots were fired. After 146 rounds were fired the elevation had increased and the muzzle had worked to the right so that the line of sight was off the target, although the clamps for both elevation and azimuth were tight; 71 hits. During this trial the two front legs of the tripod were placed on turf and the rear one on hard macadam road. The mount was then moved so that all three legs rested on the road, and 16 shots were fired to settle the mount in place.

Second trial.—Two hundred shots were fired in 27 seconds. The aim was badly deranged, the gun having worked to the left and down; 83 hits. On account of the heat radiating from the barrel it was very difficult to accurately lay the gun on the target. For the purpose of observing the effect of this heat on the aim, different members of the board fired 18 rounds.

Third trial.—Two hundred rounds were fired. The first shot struck low and the elevation gradually increased until about 100 rounds had been fired, when the bullets went over the target. The gun was relaid on the target, and while firing the remainder the aim similarly changed; 99 hits; time lost; action of gun good.

Total number of rounds fired, 1,660.

Test 12.

Omitted for the same reason as was Test 9.

Test 13.

The gun had not been cleaned or oiled since beginning the programme of tests and unburned grains of powder and dirt had accumulated in the mechanism. The gun was placed on a gravel bed about 250 yards from the target and about 15° to the right of the normal to the target.

FIRST SERIES.

One sighting shot; 999 rounds were fired in 3 minutes and 41 seconds; action of the gun excellent, no stoppages whatever occurring. The elevation gradually increased, and the gun was relaid on the target at the end of each 250 rounds. During the firing of this series it was noted that the rate of firing of the gun gradually decreased. Hits, 999. The horizontal distance between extreme hits was 14 feet 5½ inches, and the vertical distance between extreme hits was 14 feet. One cartridge case was cracked at the neck. One cartridge was not fired, due apparently to the primer being seated too deep in the shell. This cartridge was sent to the commanding officer, Frankford Arsenal, who informed the board that the primer was properly seated in the shell, but that the cartridge had been jammed so as to decrease its length. At the completion of this series 4 additional cartridges were fired by the heat remaining in the barrel.

SECOND SERIES.

This series was begun one hour after the firing of the first series was commenced. After about 1,200 rounds had been fired, it was noted that bullets or parts of the jackets were beginning to strike the water, over which the firing was done, at different points between the target and about 100 yards from the gun, although the elevation had been gradually increased during the firing until the line of sight was high above the target. As the number of bullets or jackets striking the water rapidly increased thereafter, firing was stopped at the 1,372d round, it being evident that the accuracy of the barrel was destroyed. Time of firing 1,372 rounds, 6 minutes and 50 seconds. The rate of fire decreased markedly toward the end of the firing.

All parts of the firing and feed mechanisms worked satisfactorily, and firing was not interrupted during the series. At the 1,364th round the finger was removed from the trigger and the last 8 cartridges were fired by the heat remaining in the barrel.

The exterior of the barrel was nearly red hot; the gas-lever handle was too hot to be touched, as was also the breech bolt. The heat radiating from the barrel seriously interfered with sighting; in fact, prevented accurate laying of the gun.

The gun was then cooled by the application of water to the exterior of the barrel; 14 single shots were fired, 10 of which struck the target.

Two leaky primers and 23 shells with deep indentations in rear of the neck were found. A large number of bullets were found in front of the target which showed no marks of the lands of the rifling, several bullets were found embedded in the wooden parts of the target with their points toward the gun, and a large number struck the targets sidewise. A number of jackets containing no lead and a large number of fragments of jackets were also found in front of the target.

Total number of rounds fired, 4,692.

Test 14.

The gun was then completely dismounted and cleaned and all parts of the mechanism examined. The front end of the bottom plate was bent upward and indented by the gas lever striking it; the bore in front of the chamber was deeply eroded, and all of the rifling worn out except a faint trace thereof for about 6 inches from the muzzle. A standard bullet dropped into the chamber entered the bore freely until within 8½ inches from the muzzle. The temper of the retracting springs was markedly drawn, so that they closed the mechanism slowly, although effectively. The chamber had enlarged at its rear end .001, at three-fourths of an inch from its rear end .003, and at its front end .001. No other changes occurred.

Test 15.

Prior to this test the gun was cleaned and oiled and a new barrel, rifled with a uniform twist of one turn in 8 inches, and new retracting springs were assembled in the gun; 25 cartridges loaded to give a powder pressure of 64,480 pounds per square inch were machine-loaded into a belt and fired; 23 fired automatically and 2 singly, as the lead bullets with which these cartridges were loaded jammed in the feed mechanism; 25 cartridges loaded to give a powder pressure of 34,190 pounds per square inch were machine-loaded into a belt and fired automatically in 5 seconds. Action of gun excellent.

Total number of rounds fired with this barrel 89, and with the gun 4,793.

At the completion of this test lead was scraped off the gas plunger and the latter oiled.

Test 16.

(*a*) Two cartridges, cross-filed on head to nearly the thickness of the cartridge case, were fired. When the first cartridge was fired the extractor had to be driven into its seat before the bolt could be opened. When both these shots were fired gas escaped through the mechanism to the rear, slightly scorching the hand of the firer.

(*b*) Two cartridges cut to nearly the thickness of the metal at intervals through the extractor groove were fired. The first shell was not ruptured and no gas escaped, but the second opened at four points, with much escape of gas through the parts of the gun. The extractor failed to withdraw the empty shell and was found to be broken through the inner wall of the extractor-pin hole, at which point the metal is very thin.

(*c*) A new extractor was inserted and 2 cartridges cut longitudinally nearly through the thickness of the body were fired. Both cases opened, and a small amount of gas escaped through the gun. The extractor removed both shells.

Total number of rounds fired with this barrel 95, and with the gun 4,799.

Test 17.

The gun was completely dismounted and all parts thoroughly cleaned and dried before assembling. The barrel with the 10-inch twist was assembled and both ends tightly corked. The gun was exposed 15 seconds to a blast of fine sand. Surplus sand was removed by blowing and by wiping with the bare hand; the gas lever was oscillated twice and a belt inserted in the feed mechanism; 12 shots were fired, but the mechanism was so filled with sand as to prevent full movement of the slide, which movement was completed after each shot by hand with difficulty. The gun was then dismounted and the parts found to be thoroughly filled with sand.

Second exposure.—The new barrel rifled with a uniform twist of one turn in 8 inches was assembled in the gun and the sand cleaned from all parts and exposed to the same blast of sand as the first. The sand was wiped and blown off the gun, the muzzle tapped several times on the floor, and the gun well shaken while assembling it to the mount; 39 rounds were fired with much difficulty, it being necessary to complete the movement of the slide by hand after each shot. One cartridge was stuck in the chamber, and the extractor cut a piece out of its rim.

Total number of rounds fired with first barrel 4,704; total number of rounds fired with the second barrel 39, and with gun 4,743.

Test 18.

The chamber, head space, length of bolt, etc., with a new barrel, were measured both before and after this test. Five cartridges loaded to give a powder pressure of 65,300 pounds per square inch were then fired. The extractor did not remove the first, third, and fourth shells from the chamber, and the primers fell out of their seat in all 5 cartridge cases.

Total number of rounds fired with second barrel 100, and with gun 4,804. No change occurred in the dimensions of the chamber, but the head space of the bolt increased .0035 inch. The gun was then cleaned and the parts were thoroughly oiled, and 50 rounds were fired to test the action of the mechanism, which worked satisfactorily. Total number of rounds fired with second barrel 150, and with the gun 4,854.

Test 13.

The endurance test was then repeated with the second barrel, it having previously been fired 150 rounds during these tests. Range 500 yards, target 15 by 45 feet. Two sighting shots were fired, and then 1,042 continuous rounds were fired automatically in 5 minutes and 29 seconds; 513 hits. Between 900 and 1,000 rounds the bullets or parts of the jackets commenced to drop into the water over which the firing was done, showing that the rifling had been worn out. While firing, the aim was corrected during the first, second, and third series of 250 rounds and was also corrected after each of these series. After the 1,042 rounds had been fired 4 cartridges were fired by the heat remaining in the barrel. One leaky primer and 3 cases indented at the neck were found. Total number of rounds fired with the second barrel 1,198, and with the gun 5,902.

The gun was then dismounted and all parts cleaned and examined. The bore in front of the bullet seat was deeply eroded and the rifling completely worn out about one-half the length of the bore. A bullet dropped into the chamber entered the bore freely until 15⅞ inches from the muzzle. The temper of the retracting springs was markedly drawn.

Test 19.

The gun was dismounted, all parts were thoroughly cleaned and dried, and after assembling the ends of the barrel were tightly corked and the gun immersed in a saturated solution of sal ammoniac for 5 minutes. After being exposed to a damp atmosphere for 48 hours the gun was very rusty, the gas lever could be operated only with difficulty, the hammer was rusted in the handle, and the carrier was so rusted that it would not rise until the side of the gun was tapped. Seven rounds were fired with great effort, the oscillation of the slide being completed by hand after each of these shots with difficulty. The different parts of the firing and feed mechanisms were then oiled and 93 rounds were fired automatically in 30 seconds. Total time required to fire 100 rounds, 7 minutes and 5 seconds.

Total number of rounds fired with second barrel 1,298, and with the gun 6,002.

Test 20.

(*a*) Two men loaded 1,000 cartridges, packed in clips holding five each, into four belts by machine in 10 minutes and 45 seconds. One man filled the belts by hand with cartridges loaded in clips at the rate of 1,000 rounds in 1 hour 7 minutes and 50 seconds.

Fifty cartridges were inserted in a wet belt by 2 men in 2 minutes and 50 seconds and the same number into a dry belt in 2 minutes and 25 seconds.

These tests were made with belts holding 250 rounds.

(*b*) Two belts were machine loaded and soaked in water eighteen hours. At the end of this time one belt, while wet, was handled as roughly as liable to occur in service and the 100 cartridges fired. The feed mechanism worked satisfactorily. The second belt was dried by exposure to the air, when a number of cartridges were found to be loose in the loops. The belt was handled roughly and the 100 cartridges fired. When shaken, the loose cartridges worked partially out of the belt, and these cartridges caught on the walls of the belt opening in the gun and stopped the feed until pushed fully into the belt by hand.

Total number of rounds fired with this barrel 1,498, and with the gun 6,202.

(*c*) Six belts were soaked in water eighteen hours, then loaded and fired as follows:

First belt: Loaded by machine and fired while wet. Action of feed satisfactory.

Second belt: Loaded by hand and fired while wet. Action of mechanism good.

Third belt: Loaded by machine while wet, then dried by exposure to the air and the 100 cartridges fired. After having dried, many cartridges were found to be loose in the loops. The belt was shaken, but none fell out. The second, fourth, and a number of others caught on the walls of the belt opening and stopped the feed. The cartridges were pushed well into the belt by hand, but even then the feed mechanism failed to operate properly. The belt had stretched so that all the cartridges apparently were not properly caught by the feed wheel. After firing 27 rounds, further efforts to fire from this belt were abandoned.

Fourth belt: Loaded by hand while wet, then dried by exposure to the air and firing commenced. Many cartridges were found to be loose in their loops and not fully inserted. The fourth cartridge caught on the walls of the belt opening and stopped the feed. The remaining cartridges were fully and evenly inserted in the belt by hand and fired without a stoppage.

Fifth belt: Dried by exposure to the air, then machine loaded, shaken slightly, and firing commenced. The seventh cartridge caught on the walls of the belt opening, as did several in rapid succession. An examination of the belt showed that many cartridges had slipped out of the belt from one-sixteenth to one-eighth inch. Forty cartridges were loaded by machine into the other end of the belt, the belt carefully inserted in the gun, and the cartridges fired without a stoppage; 85 rounds fired.

Sixth belt: Dried by exposure to the air, then loaded by hand. Before firing was commenced the belt was examined and all cartridges fully inserted. The 100 cartridges were fired without a stop.

Total number of rounds fired with this barrel 2,010, and with the gun 6,714.

Test 8.

Repeated to test accuracy of gun mounted on the carriage for this gun.

A new barrel rifled with one turn in 10 inches and new retracting springs were assembled in this gun.

The carriage was placed on firm turf and the two chests were empty.

First trial.—The axis of the bore was in the vertical plane containing the axis of the trail. Three sighting shots; 250 rounds were fired in 1 minute and 53 seconds. During the firing the gun worked high and was relaid three times. The shots that struck the target were scattered, many having gone over it.

Second trial.—Fired with axis of bore making an angle of about 15 degrees with trail. Two sighting shots. After firing 15 rounds with 3 jams in the feed mechanism, firing was stopped, the gun dismounted, and the parts found to be properly assembled. The failure of the feed mechanism was found to be caused by the feed belts having stretched and become distorted so that the cartridges were not spaced so as to be properly engaged by the feed wheel. The cases of two of the cartridges were caught by a cog on the feed wheel and deeply indented.

The azimuth clamp made a deep indentation in the pintle, and the latter could not be locked with this place opposite the clamp.

Total number of rounds fired with this barrel 270, and with the gun 8,184.

Test 13.

Repeated at 250 yards' range to determine life of the new barrel inserted in gun before making preceding test; 1,318 rounds were fired automatically in 9 minutes. After firing about 1,100 rounds the bullets or their jackets commenced to strike the water between the gun and target. The firing was stopped, as very few shots struck the target.

On account of the imperfect condition of the first few loops in each belt, which caused a jam in the feed mechanism, the first five cartridges were removed from all belts used after the first. The rate of fire decreased markedly during the firing of the last 300 rounds. The gun was relaid on the target at the end of each belt. The gun was dismounted and the bore of the barrel found deeply eroded, the lands of the rifling worn out except near the muzzle, and a standard bullet dropped in the bore entered until 11 inches from the muzzle. The temper of the retracting springs was drawn. The edge of the ratchet-lever pawl was also broken.

Total number of rounds fired with this barrel 1,588, and with gun 9,502.

RESULTS OF PROGRAMME OF TESTS WITH VICKERS SONS & MAXIM SOLID ACTION AUTOMATIC MACHINE GUN.

Mr. H. C. Sheridan and Mr. James Huber, representatives of Vickers Sons & Maxim, were present during the tests of the guns submitted by this company. Mr. Sheridan informed the board that, with the exception of those parts which it was necessary to change in order to adapt this gun to the new army cartridge, the solid action gun was the same one previously tested by the Ordnance Department of the Army.

Test 1.

(*a*) All parts were completely dismounted and examined by the members of the board.

(*b*) This gun is composed of 93 components parts, exclusive of the front and rear sights. Included in this number are 7 screws, 14 pins, 8 flat springs, 4 helical springs, and 1 spiral spring.

(*c*) The interior diameters of the chamber and the head space were measured.

Test 2.

One hundred rounds were fired automatically to test the action of the gun. The mechanism was closed with difficulty when the first cartridge was inserted in the chamber, and when removed the case was found to have been dented; when the second cartridge was inserted in the chamber the mechanism was also closed with difficulty, and when removed the rim of the cartridge case was found to have been cut and the body dented. These cartridges were probably dented by the feed-block pawls. The breech mechanism was then oiled, 2 other cartridges inserted in the belt, and the 100 rounds fired without further difficulty. Total number of rounds fired, 100.

Test 3.

The velocity at 53 feet from the muzzle was found to be 2,307 feet per second. Total number of rounds fired, 214.

Test 4.

(*a*) A belt was loaded with 80 ball and 20 dummy cartridges, every fifth being a dummy. The following 15 ball cartridges were then removed, viz: The 7th, 16th, 22d, 23d, 34th, 43d, 48th, 54th, 61st, 67th, 68th, 77th, 78th, 87th, and 93d. The time required to run the belt through the gun and fire 59 cartridges was 2 minutes and 23 seconds. Six of the ball cartridges were not fired, due to improper manipulation of the gun. When firing was stopped by the presence of a dummy in the chamber or by a blank space in the feed belt, it was necessary to throw the operating lever forward, pull the feed belt so as to bring the next cartridge therein opposite the extractor, to release the operating lever, and to repeat these operations.

(*b*) A belt was loaded with 25 ball cartridges; the bullets of three of the cartridges were inserted one-fourth of an inch too far in the case, and of three others pulled one-eighth of an inch out of the case, and the cartridges fired. The length of the slot for the cartridges in the feed block is only slightly greater than that of the standard cartridge, and the 3 cartridges with the bullets protruding one-eighth of an inch bound in the feed block, but were forced in and fired.

Total number of rounds fired, 184.

Test 5.

The removal and reinsertion of these parts were done by the same member of the board who made this test with the other guns. The time required in each case is that elapsing from the signal to stop firing until firing was resumed.

(*a*) The lock was removed and reinserted in 16 seconds.

(*b*) The extractor was removed and reinserted in 4 minutes and 2 seconds.

(*c*) The firing pin was removed and reinserted in 3 minutes and 51 seconds.

(*d*) No other parts were removed.

Total number of rounds fired, 280.

Test 6.

(*a*) Three cartridges were thoroughly coated with resin, and as they could be inserted in the belt only with great difficulty, they were inserted in the feed block by hand. These 3 cartridges were satisfactorily fired and extracted.

(*b*) The design of this gun is such that if the extractor is removed or broken it would be impossible for a cartridge to be removed either from the feed belt or from the chamber, and therefore no firing was attempted.

Total number of rounds fired, 283.

Test 7.

The gun was mounted on the tripod and fired on the same wooden platform from which this test was made with the other guns.

(*a*) The maximum angle of depression obtainable with the mount was 27 degrees; 200 rounds were fired in 36 seconds; action of feed and of gun excellent, aim not deranged.

(*b*) The greatest angle of elevation obtainable with the mount is 17 degrees and 9 minutes; 200 rounds were fired in 35 seconds; action of feed mechanism and of gun excellent; elevation after firing, 17 degrees.

(*c*) As the elevation of the gun could not be varied by means of the elevating screw as rapidly as desired, the gun was disconnected from the screw and elevated and depressed by hand between the limits of 16 degrees elevation and 27 degrees depression; 196 rounds were fired in 1 minute and 12 seconds; action of feed mechanism excellent. Four cartridges were not fired when the gun was being depressed, due to the failure of the counter-recoil spring to fully close the breech mechanism and release the safety sear. This mount did not change position during the firing.

Total number of rounds fired, 1,846.

Test 8.

Before beginning this test the gun was thoroughly cleaned and oiled; 5 sighting shots were fired; 200 rounds were fired automatically in 38 seconds. Time of firing the first 100 was 13 seconds; 200 hits on target, the horizontal distance between extreme shots was 5 feet, and the vertical 5½ feet. It was estimated that 90 per cent of the hits were contained within a space 3 feet square; action of gun excellent. The line of sight worked to the right and high.

Total number of rounds fired, 488.

Test 9.

As the design of this gun does not permit its rate of automatic fire to be varied, this test was omitted.

Test 10.

As the mount is provided with stops for limiting the movement of the gun in azimuth, they were clamped so as to limit the oscillation of the gun within the angle subtended by the length of the target. One sighting shot; 200 rounds were fired with the gun being constantly moved in azimuth in 34 seconds, the first 100 rounds being fired in 11½ seconds; 164 hits on target; action of gun excellent.

Total number of rounds fired, 689.

Test 11.

First trial.—Seven sighting shots; elevation 970 yards, deviation 0. After firing 134 shots it was noticed that the gun was not properly clamped in its mount and the firing was stopped.

Second trial.—Two sighting shots; elevation and deviation the same; 198 rounds fired, time lost, 58 hits. The line of sight moved upward and to the right of the target. Firing was stopped during the second belt by a bullet having been pulled out of the cartridge case in the feed block.

Third trial.—Two sighting shots; elevation and deviation the same. After firing the 18th shot the automatic action of the gun failed, due to the accumulation of the residue in the gas chamber. The residue was removed and the piston and its bearings oiled.

Fourth trial.—Two hundred rounds were fired in 40 seconds, the first 100 being fired in 11½ seconds; action of the gun excellent; 192 hits on target. The horizontal distance between extreme shots was 12, and the vertical 13 feet.

Total number of rounds fired, 1,250.

Test 12.

As this gun is designed so that its rate of automatic fire is constant, this test was omitted.

Test 13.

FIRST SERIES OF 1,000 ROUNDS.

All parts of the gun were thoroughly cleaned and oiled and the water jacket filled. The tripod was placed on solid ground. Two sighting shots. Firing was stopped at the 9th shot by the breaking of the mainspring, which was replaced, and firing resumed. At the 187th shot the handle on the operating lever broke off and firing was stopped. The trunnion pin clamp failed to properly secure the gun in the mount, and in consequence the gun vibrated in the mount and seriously damaged the aim. An examination of the empty shells showed 7 pierced primers, 1 leaky primer, and 5 shells showing signs of rupture about three-fourths of an inch in front of the head.

Total number of rounds fired, 2,035.

Second trial.—At the first shot automatic action of the gun ceased and an examination of the gun showed that in tightening the trunnion pin the sides of the casing were pressed in against the action bar and prevented the closing of the mechanism.

Third trial.—After firing about 200 rounds one cartridge was not fired, which occurred again at the 234th shot, and an examination of these two cartridges showed that the primers had not been struck by the firing pin. Time of firing 234 rounds, 1 minute and 56 seconds. A new lock was inserted and the firing resumed. At the end of the 4th belt, or the 500th round, the jacket was refilled with water. Time required to fill the water jacket, 1 minute. At the 602d round the operating lever, which had not been properly fastened to the crank, worked loose and firing was stopped. The elevation had not changed, but the hits were badly scattered horizontally on the target, due to the failure of the azimuth clamps to firmly secure the mount.

Total number of rounds fired, 2,638.

Fourth trial.—Before this trial the operating lever was properly assembled to the crank, the mechanism was oiled, and the jacket filled with water; 972 rounds were fired in 6 minutes; 28 cartridges were not fired, as the operating lever had not been properly adjusted so as to insure the release of the safety sear. This defect was corrected. The horizontal distance between extreme shots on the target was 9 and the vertical 8 feet.

Total number of rounds fired, 3,610.

SECOND SERIES OF 2,000 ROUNDS.

The mechanism was oiled and the jacket filled with water, and 1,991 rounds fired in 25 minutes and 5 seconds. Many of the shots struck below the target. The horizontal distance between extreme hits was 12 and the vertical 6 feet. During this series the water jacket was refilled at the end of the 4th, 6th, 10th, and 12th belts, or after firing 500, 750, 1,250, and 1,500 rounds. During the firing of the 7th belt several primers were not struck by the firing pin. A new lock was inserted, which failed to fire several cartridges in succession, and was replaced by the first one. During the firing of the 13th belt the automatic action constantly failed, it being necessary to close the breech mechanism by means of the operating lever; these failures were due to the accumulation of residue in the gas chamber. The piston and the yoke bearings were oiled, after which the gun worked fairly well, it being necessary after different shots to close the mechanism by means of the operating lever. The primer of one cartridge was found to be only slightly dented by the firing pin and was inserted in the gun and fired.

Total number of rounds fired, 5,601.

As the accumulation of residue in the gas chamber frequently prevented the springs from closing the mechanism, this gun was withdrawn by Mr. Sheridan, the representative of Vickers Sons & Maxim, who stated to the board that the company decided to submit it for test at such a late date that sufficient time was not available for the experimental work necessary for overcoming the interference of the residue accumulated in the gas chamber.

RESULTS OF PROGRAMME OF TESTS WITH VICKERS SONS & MAXIM STANDARD PATTERN AUTOMATIC MACHINE GUN.

Test 1.

(*a*) The gun was completely dismounted and all component parts examined by the board.

(*b*) This gun is composed of 88 component parts, exclusive of the front and rear sights. This number includes 4 screws, 9 pins, 4 helical springs, and 8 flat springs.

(*c*) The interior diameters of the chamber and the head space were measured.

Test 2.

One hundred rounds were automatically fired into a stop butt, and the action of the gun was found to be excellent.

Total number of rounds fired, 100.

Test 3.

The velocity at 53 feet from the muzzle was found to be 2,267 feet per second.

Total number of rounds fired, 266.

Test 4.

(*a*) Eighty ball and 20 dummy cartridges were loaded into a belt, every 5th being a dummy, and then the following 15 ball cartridges were removed, viz, the 7th, 16th, 22d, 23d, 34th, 43d, 48th, 54th, 61st, 67th, 68th, 77th, 78th, 87th, and 93d. This belt was then run through the gun and 51 of the ball cartridges fired; 14 were not fired, due to the failure of the operator to properly manipulate the mechanism. When firing was stopped by the presence of a dummy in the chamber, or by a blank space in the feed belt, it was necessary to throw the operating lever forward, pull the feed belt so as to bring the next cartridge opposite the extractor, release the operating lever, and to repeat these operations.

(*b*) Twenty-five cartridges were loaded into a belt, the bullets of 3 cartridges were inserted one-fourth of an inch too far in the case, and of 3 others withdrawn three-thirty-seconds of an inch, and the cartridges fired without a hitch.

Total number of rounds fired, 176.

Five cartridges with the cases dented as follows were inserted in the feed block, one at a time, and fired: One ball cartridge with the case slightly flattened, one with the case dented, one with the case flattened at the neck, one with the body of the case flattened, one with the case dented longitudinally. These cartridges were properly inserted in the chamber by the counter-recoil spring and were extracted and ejected automatically.

Total number of rounds fired with this barrel 13,839, and with the gun 19,703.

Test 5.

The parts were removed and replaced by the same member of the board who made this test with the other guns. The time recorded in each case is that elasping from the signal to stop firing until firing was resumed.

(*a*) The lock was removed and reinserted and firing resumed in 19 seconds.

(*b*) The extractor was removed and reinserted and firing resumed in 1 minute and 12 seconds.

(*c*) The firing pin was removed and reinserted and firing resumed in 3 minutes and 19 seconds.

(*d*) No other parts were removed.

Total number of rounds fired, 244.

Test 6.

(*a*) Three cartridges were thoroughly coated with resin, and on account of the difficulty of inserting them in the belt, were inserted in the feed-block by hand. These cartridges were fired and extracted satisfactorily.

Total number of rounds fired, 269.

Test 7.

The gun mounted on its tripod was fired from the same platform used in the tests of the other guns.

(*a*) The maximum angle of depression obtainable with the mount was 29 degrees; 200 rounds were fired in 2 minutes and 34 seconds. Firing was stopped three times during this series by the failure of the parts to recoil the required distance, and in each case the motion was completed by means of the operating lever. Aim not changed.

(*b*) The maximum angle of elevation obtainable with the mount was 18 degrees; 200 rounds were fired in 45 seconds. The feed mechanism failed once to present a cartridge in front of the lock. Aim not deranged.

(*c*) In making this test the gun was disconnected from the elevating screw and was elevated and depressed by hand; 200 rounds were fired in 37 seconds, the gun being kept constantly in motion between the greatest depression and elevation obtainable. The angle of variation was about 40 degrees; action of feed excellent. Aim not deranged.

Total number of rounds fired, 1,889.

Test 8.

The gun was cleaned and oiled and the jacket filled with water; 4 sighting shots; 200 rounds were fired in 39 seconds. For 175 of the 180 hits the horizontal distance between extreme shots was 5 feet, and the vertical 6 feet. Five shots struck some distance from the other 175. Nearly all of the hits were near the bottom of the target in a space 5 feet horizontally and 3 feet vertically. During the firing the line of sight worked up 2 feet on the target. Three leaky primers were found.

Second trial.—One hundred and ninety-seven shots were fired, time lost, with 187 hits. The horizontal distance between extreme shots was 6 feet and the vertical 9 feet. The last few shots struck below the target. During the firing of this series one cartridge case ruptured three-fourths of an inch in front of the head; one shell showed signs of rupture 1 inch in front of the head; one shell was split in the neck; one primer leaked, and one cartridge was found with a rim 0.069 inch thick, which was too great for the extractor to engage. The firing was stopped by the ruptured shell and also by the thick-rimmed cartridge. Aim not deranged. After firing the 197th round, one shot was fired which struck near the first of the series, showing that the dispersion on the target was due to the vibration of the gun and mount.

Total number of rounds fired, 671.

Test 9.

As this gun is designed to have but one rate of automatic fire, this test was omitted.

Test 10.

Four sighting shots. The movement of the gun in azimuth was limited within the angle subtended by the target by the clamps on the mount; 200 rounds were fired with the aim constantly oscillated in azimuth, in 46 seconds, the first 100 being fired in 12 seconds; 145 hits; action of gun good; line of sight worked high; two shells showed signs of rupture about one-half inch in front of the head and one primer leaked.

Total number of rounds fired, 875.

Test 11.

Seven sighting shots; elevation 900 yards, deviation 0; 200 rounds were fired, time lost, with 61 hits, nearly all of the bullets striking below the target. After firing 100 rounds the firing was stopped to resight the gun.

Second trial.—Seven sighting shots; elevation 970 yards, deviation 2½ points to the left; 200 rounds were fired, time lost, 159 hits. The line of sight moved 9 feet to the right and 6 feet high on target, the trail of the mount having moved to the left. Action of gun good.

Total number of rounds fired, 1,289.

Test 12.

As this gun is designed to have but one rate of automatic fire, this test was omitted.

Test 13.

This test was made at a range of about 250 yards, the gun being placed on solid ground about 15 degrees to the right of the normal to the target.

FIRST SERIES.

The gun was cleaned and oiled and the jacket filled with water. Two sighting shots were fired. After firing 587 rounds in 2 minutes and 4 seconds the link pin broke and was replaced. About 90 per cent of the shots fired struck the target and the horizontal distance between extreme hits was 8 feet and the vertical 14 feet; for a majority of the shots the horizontal distance between extreme hits was 4 feet; the remainder of the shots struck below the target.

Total number of rounds fired, 2,478.

Second trial.—The gun was oiled and the jacket filled with water; 1,000 rounds were fired in 3 minutes and 2 seconds. The great majority of the shots struck the target. The horizontal distance between extreme hits was 7 feet and the vertical 12 feet; a number of shots struck below the target. At the end of the firing the feed and firing mechanism were too hot to be handled.

Total number of rounds fired, 3,478.

SECOND SERIES.

This test was commenced one hour after the preceding series of 1,000 was finished. The mechanism was thoroughly oiled and the jacket filled with water; 2,000 rounds were fired in 11 minutes and 42 seconds. The water jacket was refilled at the end of the 4th, 8th, and 12th belts, or after firing 500, 1,000, and 1,500 rounds.

During the firing of the 13th belt the automatic action of the gun stopped a number of times, due to the energy of the recoiling parts being too small to fully open the mechanism against the tension of the counter-recoil spring, which was decreased, and thereafter the action of the gun was satisfactory. The majority of these shots struck the target and the horizontal distance between extreme hits was 8 feet and the vertical 6 feet, the remainder of the shots striking below the target.

Total number of rounds fired, 5,478.

THIRD SERIES.

The mechanism was oiled and the jacket filled with water. This series was commenced 2 hours and 20 minutes after beginning the series of 2,000 rounds; 3,000 rounds were fired in 22 minutes and 45 seconds. The jacket was refilled after firing 1,000, 1,625, and 2,250 rounds. Two cartridges which failed to fire in the 8th and 9th belts were afterwards inserted in the gun and fired. The action of the gun was excellent until the latter part of the 10th belt, when several failures to fire occurred and a new lock was inserted. While firing the 18th belt the link pin broke and was replaced, which stopped the firing 4 minutes and 6 seconds. During the firing of the 18th belt the mechanism frequently failed to recoil the required distance and in each case was completed by means of the operating lever. At the end of the 18th belt the tension of the counter-recoil spring was again decreased. During the firing of about the first 40 cartridges from the 19th belt the counter recoil of the parts had to be completed by means of the operating lever. The recoiling parts were then thoroughly oiled, after which the action of the mechanism was satisfactory. The time of firing the last belt was 23 seconds, showing that the rate of fire had decreased from 600 to 326 rounds per minute. The horizontal distance between extreme shots on the target was 4 feet and the vertical 5 feet. At the end of this series a cartridge was inserted in the chamber, but the remaining heat was not sufficient to fire it.

Total number of rounds fired, 8,478.

Special test for accuracy.

After firing the series of 1,000, 2,000, and 3,000 rounds of Test 13, the gun was dismounted and the barrel found to be deeply eroded in the bullet seat and the rifling badly worn throughout the bore, no trace of rifling being visible for about one-fourth of its length. In order to test the accuracy of the barrel in this condition it was decided to fire 100 rounds very slowly at 500 yards' range, the tripod being placed on a solid floor. The jacket was filled with water and the mechanism thoroughly cleaned and oiled. Five sighting shots were fired; 15 single shots were fired, all of which struck the target; 85 shots were then fired automatically, all of which struck the target. During the firing of these 85 rounds the recoil was not completed six times; 250 rounds were then fired automatically, the recoil not being completed 7 times. Of the 355 shots fired in this test 305 struck the target.

Total number of rounds fired, 8,833.

As a result of this special test it was decided to continue the firing of the 4th or continuous firing series of Test 13. The gun was oiled and the jacket filled with water; 2 sighting shots; 3,620 rounds were fired in 40 minutes and 15 seconds; horizontal distance between extreme hits was 15 feet and the vertical 11 feet. During the firing of the first belt the mechanism was closed by means of the operating lever twice. The action of the gun was good during the firing of the 2d, 3d, 4th, 5th, and 6th belts. During the firing of the 4th belt one bullet, or the jacket stripped therefrom, struck the water midway between gun and target. Near the end of the 6th belt the plug in the water jacket was blown out by escaping steam. During the firing of the 7th belt the operation of the mechanism was twice completed by means of the operating lever, and at the end of this belt, or after the 875th shot, the water jacket was refilled and the gun oiled. The 8th and 9th belts were fired without a hitch. During the firing of the 10th belt the plug in the water jacket was blown out by escaping steam and firing was stopped by the barrel, which had been expanded by the heat generated, binding in its rear bearing. The barrel was cooled until sufficiently contracted to relieve the binding, after which it was oiled. When firing was thus stopped 1,185 rounds had been fired in 11½ minutes. During the firing of the 8th, 9th, and 10th belts several bullets, or parts of the jackets thereof, struck the water between the gun and the target. After firing the 65 rounds left in the 10th belt the jacket was refilled with water and the gun oiled. During the firing of these 65 rounds the motion of the moving parts was completed by means of the operating lever 8 times, and a bullet, or part of the jacket thereof, struck the water between the gun and target. The mechanism of the gun operated properly during the firing of the 11th, 12th, and 13th belts. During the firing of the 12th belt one bullet, or part of the jacket thereof, struck the water between the gun and target, and during the 12th belt the plug in the water jacket was blown out by escaping steam. During the firing of the 14th belt the motion of the recoiling parts was completed by means of the operating lever 6 times, and after two cartridges were not struck by the firing pin the lock was replaced by a new one. At the end of the 14th belt the jacket was refilled with water and the mechanism oiled. During the firing of the 15th belt the motion of the recoiling parts was completed by means of the operating lever 18 times, and during the 16th belt 12 times. During the firing of the 16th belt 2 cartridges were not fired and the lock was again changed. The motion of the recoiling parts was completed by means of the operating lever 3 times in the 17th, 5 times in the 18th, and twice in the 20th belt. The plug in the water jacket was blown out by escaping steam during the 17th belt, and upon its completion the jacket was refilled and the gun oiled. During the firing of the 14th, 15th, 16th, 17th, 18th, 19th, and 20th belts 24 bullets, or parts of the jackets thereof, struck the water between the gun and target, one of which fell about 10 feet from the muzzle. During the firing of the 21st belt the operating lever was maneuvered by hand 21 times, and at its completion the jacket was filled with water and the mechanism oiled. During the firing of the 22d belt the operating lever was maneuvered 10 times, and of the 24th belt 21 times. The plug was blown out of the water jacket, and steam escaped during the firing of the 23d belt. The first 24 belts, or 3,000 rounds, were fired in 35 minutes, when the jacket was refilled with water, the gun oiled, and the tension of the counter-recoil spring reduced. During the firing of the 21st, 22d, 23d, and 24th belts 19 bullets, or parts of the jackets thereof, struck the water between the gun and target. The motion of the recoil parts was completed by means of the operating lever 5 times during the 25th belt, 3 times during the 26th, 9 times during the 27th, 6 times during the 28th, and 6 times during the 29th belt. During the firing of the last 5 belts 6 bullets, or parts of the jackets thereof, struck the water between the gun and target. During the firing of these 3,620 rounds the water jacket was refilled and the gun oiled 6 times.

Total number of rounds fired, 12,455.

The barrel was replaced by a new one, the jacket filled with water, the gun oiled, and the headspace decreased 0.003 inch by a washer. Two sighting shots; 5,864 rounds were fired in 45 minutes and 20 seconds. The water jacket was refilled and the mechanism oiled, after the 7th, 10th, 13th, 17th, 20th, 24th, 28th, 31st, 34th, 38th, 41st, and 44th belts, or after firing 875, 1,250, 1,625, 2,125, 2,500, 3,000, 3,500, 3,875, 4,250, 4,750, 5,125, and 5,500 rounds. After firing 310 rounds in 55 seconds the counter-recoil spring broke and a new one was inserted. While firing the 6th belt the feed mechanism jammed. The first 7 belts, or 875 rounds, were fired in 7 minutes and 50 seconds. While firing the 9th belt 2 shots struck the water at a considerable distance from the line of fire, as also did 3 while firing the 10th belt. While firing the

12th belt one bullet struck the water about midway between the gun and target. While firing the succeeding belts it was noted that either a number of bullets, or parts of the jackets thereof, struck the water at different points from a short distance from the muzzle to the target. After firing the 17th belt residue was scraped from the muzzle and the front bearing of the barrel was again oiled. After firing the 28th belt the muzzle bearing of the barrel was again oiled. While firing the 29th belt the feed-pawl spring broke and a new feed block was inserted. The first 34 belts were fired in 34 minutes. While firing the 41st belt one cartridge jammed in the feed mechanism and stopped the firing, and at another time the mechanism had to be closed by means of the operating lever. While removing the cartridge jammed in the feed mechanism it was dropped into the casing, and the gun had to be removed from the mount in order to get the cartridge out of the mechanism. During the firing of this belt the gib spring broke and had to be replaced. While this was being done considerable water ran into the casing from the jacket. The horizontal distance between extreme hits on the target was 16 feet and the vertical 15 feet.

Total number of rounds fired with this barrel, 5,864, and with the gun, 18,319.

Test 14.

The gun was then dismounted and the parts cleaned and examined. The lifting lever was found to be badly worn, the first barrel used in the test of this gun was badly eroded, and the rifling markedly worn away. A bullet dropped into the bore entered 3 inches beyond the bullet seat. The chamber of this barrel enlarged 0.004 of an inch in diameter at its rear one, 0.001 of an inch in diameter three-fourths of an inch from the rear end, 0.002 of an inch in diameter in the rear of the neck, and 0.003 of an inch in diameter at the neck. The headspace was not changed.

Test 15.

Twenty-five cartridges loaded to give a powder pressure of 34,190 pounds per square inch were loaded into a belt and fired automatically; motion of the recoiling parts had to be completed by means of the operating lever for the first 7 shots, when the tension of the counter-recoil spring was reduced 2 pounds; the remaining 18 shots were then fired without a hitch.

Twenty-five cartridges loaded to give a powder pressure of 64,480 pounds per square inch were loaded into a belt and fired without a hitch; the rate of firing was, however, noticeably higher. Total number of rounds fired with first barrel, 12,505, and with the gun, 18,369.

Test 16.

(*a*) Two cartridges cross-filed on head to nearly the thickness of the metal were fired with marked escape of gas into the mechanism; no parts were injured.

(*b*) Two cartridges cut at intervals through the extractor groove nearly into the powder space were fired with a noticeable escape of gas into the mechanism; no parts were injured.

(*c*) Two cartridges cut longitudinally nearly through the body of the shell were fired with small escape of gas into the mechanism; no parts were injured.

Total number of rounds fired with first barrel, 12,511, and with the gun, 18,375.

Test 17.

The gun was dismounted, all parts thoroughly cleaned and dried before assembling, the mechanism closed, and both ends of the barrel corked. The gun was subjected to a blast of sand for 13 seconds, then removed and the surplus sand blown and wiped off with the bare hand, and 100 rounds fired in 4 minutes and 11 seconds. The parts of the firing mechanism of this gun are so thoroughly inclosed that only a small amount of sand reached the working parts; this, however, was sufficient to prevent the lock from being fully opened and closed by the energy of recoil of the moving parts and it was necessary to complete the movement by means of the operating lever after each shot. One leaky primer was found.

Total number of rounds fired from this barrel, 12,611, and from the gun, 18,475.

Test 18.

Five cartridges loaded to give a powder pressure of 75,630 pounds per square inch were fired, the mechanism operating satisfactorily.

Total number of rounds fired from this barrel, 12,616, and from the gun, 18,480.

The gun was then dismounted and the mechanism examined, which was found to be practically in as good condition as when the programme of tests was begun. The interior diameter of the rear end of the chamber had increased 0.001 of an inch, and just in rear of the neck 0.002 of an inch. The headspace increased 0.001 of an inch.

Supplemental test.

The gun was dismounted and all parts thoroughly cleaned and well oiled and 125 rounds fired in 15 seconds for the purpose of testing the action of the mechanism of the gun at this period of the tests.

Total number of rounds fired from this barrel, 12,741, and from the gun, 18,605.

Test 19.

The gun was dismounted, all parts thoroughly cleaned and dried, and after assembling, the ends of the barrel were tightly corked and the gun immersed in a saturated solution of sal ammoniac for 5 minutes. It was then exposed in a damp atmosphere for 48 hours, at the end of which time all parts were badly rusted. The catch on the lid could not be opened with the hand, the extractor was rusted to the lock, and the mechanism could not be opened and closed with the operating lever without the use of a hammer. The lock was opened and closed several times in order to relieve its binding. A belt of 100 cartridges was then inserted in the gun and the first 4 shots fired by operating the parts by means of the operating lever, the energy of recoil not being sufficient to operate the gun automatically. The working parts were then thoroughly oiled and 95 rounds fired, the mechanism being closed after the first of these rounds with the hand, after which the gun worked satisfactorily, except that 1 cartridge was not struck by the firing pin. Total time of firing 99 rounds, 3 minutes and 50 seconds.

Total number of rounds fired with this barrel, 12,840, and with the gun, 18,704.

Test 20.

(*a*) Eight belts were loaded by 2 men using the belt-loading machine, the cartridges being packed in clips of 5 each, in 15 minutes and 20 seconds. During this test the feed-pawl spring broke and was replaced. One man loaded the belts by hand, the cartridges being packed in clips of 5 each, at the rate of 1,000 rounds in 1 hour 30 minutes and 40 seconds.

Two men loaded 250 rounds into 2 wet belts by machine in 4 minutes and 32 seconds. One man loaded 125 rounds into a wet belt by hand in 21 minutes and 35 seconds. Another man similarly loaded a wet belt in 22 minutes and 15 seconds.

Each belt used in these tests held 125 cartridges.

(*b*) Two belts were loaded by machine, then soaked in water 23 hours. At the end of this time one belt was handled as roughly as is liable to occur in service and the 125 cartridges fired. Three of the cartridges, when the belt was roughly handled, worked slightly out of the belt. As the length of the opening in the feed box is only slightly longer than a cartridge, the pull exerted on the belt by the feeder must be sufficiently great to enable the rounded edges of the belt opening to complete the insertion of the cartridge in the belt before the latter can be moved forward and bring the next cartridge in position to insure its engagement by the extractor. As the energy of the moving parts was not sufficiently great to operate the feed mechanism in the case of these 3 projecting cartridges, it was augmented in each case by means of the operating lever.

The other belt was hung up until dry, then roughly handled, and the 125 rounds fired in 2 minutes and 35 seconds. There were 4 failures of the feed mechanism due to the same cause described with the foregoing belt. In forcing the feed mechanism with the operating lever, 1 cartridge shell was badly deformed by the belt feeders.

(*c*) Six belts were soaked 23 hours in water, then loaded and fired as follows:

First belt: Loaded by machine and the 125 cartridges fired, while belt was wet, in 14 seconds. The feed mechanism worked well.

Second belt: Loaded by hand and 119 of the 125 cartridges fired while the belt was wet. Owing to the great difficulty of inserting every cartridge fully into a wet belt, some projected farther than others and necessitated the use of the operating lever as described under the first belt of test (*b*). While using the operating lever 5 cartridges were fed through the gun without being fired. In one case the feed-block pawl caught 2 instead of 1 cartridge and necessitated the removal of one of the cartridges before the jammed cartridge could be removed.

Third belt: Loaded by machine while wet, then dried by exposure to the air. The 125 cartridges were fired in 13¼ seconds. Action of feed excellent. During the firing of this belt water leaked through the rear bearing of the barrel into the mechanism.

Fourth belt: Loaded by hand while wet, then dried by exposure to the air. The 125 cartridges were fired in 14⅕ seconds. With the exception of one cartridge jamming in the feed mechanism the operation of the latter was satisfactory.

Fifth belt: Dried by exposure to the air, then loaded by machine. The 125 cartridges were fired in 14 seconds. Action of feed mechanism good.

Sixth belt: Dried by exposure to the air, then loaded by hand. The 125 cartridges were fired in 14 seconds. Action of feed mechanism good.

Total number of rounds with this barrel 13,834, and with the gun 19,698.

Test 8.

Repeated to test accuracy of gun on light tripod.

The gun was thoroughly cleaned and oiled, the jacket filled, and a new barrel rifled with a left-hand twist of one turn in 10 inches assembled in the gun. The counter-recoil-spring case was provided with an indicator showing the tension of the spring which was set at 7 pounds.

The tripod was placed on firm turf. Two sighting shots were fired; 248 rounds were fired in 4 minutes and 22 seconds, during which two stops were made to relay the gun on the target. This tripod is so light that the front legs were raised off the ground each shot and the bearing of the top carriage on the pintle so loose that the gun vibrated markedly on the mount. The tension of the counter-recoil spring decreased 2 pounds, the tension screw being rotated by the vibration.

Total number of rounds fired with this barrel, 250, and with the gun, 20,503.

Test 13.

Repeated at a range of 250 yards to determine the number of rounds that can be fired with an empty water jacket.

The gun was thoroughly oiled, jacket emptied, and counter-recoil spring set at 8 pounds. One sighting shot; 547 rounds were fired in 6 minutes, when firing was stopped by failure of recoiling parts to move the required distance to the rear. The feed mechanism failed to operate once during the first belt and 15 seconds were consumed in removing the jam; 18, 25, 17, and 19 seconds were consumed in inserting the second, third, fourth, and fifth belts, respectively, and the gun was relaid on the target at the end of each belt.

After firing 543 rounds the recoiling parts failed to move rearward sufficient to reload the gun; 4 more rounds were fired by hand to ascertain the cause, which was found to be due to the barrel having been badly bent and a large hole formed in its under side. After about 450 rounds were fired most of the bullets or their jackets struck between the gun and target. The gun was then examined and the muzzle attachment and disk on the muzzle of the barrel were deeply coated with lead. The bore of the barrel was markedly enlarged throughout its length, the lands of the rifling wore out, and the barrel deeply eroded at different points. At 11 inches from the rear end the barrel was swollen and an elliptical hole with a major axis of 1 inch and minor axis of five-eighths of an inch formed in its under side. The barrel did not bind in either of its bearings.

Total number of rounds fired with this barrel, 797, and with the gun, 21,050.

PART II.

RESULTS OF PROGRAMME OF TESTS OF MOUNTS, PACK OUTFITS, AND CARRIAGES.

The following material was submitted to the board for test, viz:

With Colt gun: Tripod mount; carriage; aparejo with frame and hangers for packing tripod, gun, loading machine, and ammunition.

With Vickers Sons & Maxim gun: Combined tripod and carriage; galloping carriage for sleigh mount; sleigh mount and three pack saddles, one carrying the gun, sleigh mount, and three ammunition boxes, and each of the other two one ammunition chest.

Test 1.

A detailed examination of the packs, mounts, and carriages was made by the board and the principal features of each found to be as follows, viz:

A description of the tripod and carriage for the Colt gun is included in that of the gun.

The pack outfit for the Colt gun consists of an aparejo, on which is placed a metal frame (see Pl. 14) the off side of which is provided with two hooks, to which the hanger carrying the tripod is hung, and the nigh side provided with two hooks from which is suspended the hanger carrying the gun and loading machine. The top of the frame is shaped to receive the gun, tripod, or four ammunition boxes. The frame is secured on the aparejo and to the mule by a belly cincha. A cargo cincha secures the load to the boot of the aparejo.

A description of the combined carriage and tripod, sleigh mount, and galloping carriage for the Vickers gun is included in that of the gun.

One of the three pack saddles is arranged to carry the gun on one side, three boxes of ammunition (750 rounds) on the other, and the sleigh mount on top of the frame. The other two saddles are arranged to carry on top of the frame a steel ammunition chest, the same as on the galloping carriage, each chest containing seven ammunition boxes, or 1,750 rounds. The first pack saddle (see Pl. 15) consists of two metal side bars, to which is riveted a metallic frame shaped to receive the sleigh mount. The ends of each side bar are inserted in pockets near the top of a hair pad, the outer covering of which is leather and the under flannel cloth. Longitudinal seams divide each pad into one large compartment under the side bars, and four smaller compartments below the former. A corrugated sheet-metal strip is attached to each pad, about 6 inches below the side bar, upon which the lower part of the hanger bears. On each side of the metallic frame are two hooks on which a hanger is hooked. Three squares are fastened by clips to the lower edge of each side bar to which the three cinchas are attached by their respective straps. These straps are provided with buckles. A breast strap and a breeching with crupper are attached to rings provided on the pad and frame. The other two saddles are the same as the first except that the metallic frame is shaped to receive a steel ammunition chest. A felt pad is provided for insertion between the mule's back and the saddle pad.

It being evident during the preliminary drills that the method of securing the three cinchas to the saddle by means of straps with buckles was impracticable, the saddle on which the gun and sleigh mount were packed during the test was modified as follows, viz:

First. The three cinchas and their straps were discarded. The upper ends of two link straps were attached to the outer squares on each side bar, and their lower ends to a 3-inch ring. These two rings on each side were connected horizontally by a third strap. The saddle was secured to the mule by two cavalry cinchas, one attached to the two front and the other to the two rear 3-inch rings. The lower ends of the side hangers were held down by a third cincha.

Second. The crupper strap was attached to the rear crosspiece of the metallic frame, consequently as the pack rocked an unnecessary strain was brought on the mule's tail. This was obviated by shortening and then attaching the crupper strap to an evener strap, the ends of which were fastened to the rear upper D rings on the saddle pads.

Third. The straps for securing the sleigh mount to the frame were discarded and small ropes with rings used instead.

Test 2.

A detachment was formed for each outfit and drilled in the firing, packing, etc., of each of the guns and their pack outfits.

Test 3.

Being on the march, the pack train was halted, the Colt gun, tripod, and 500 rounds of ammunition were unpacked, the gun set up, and firing commenced in 1 minute and 8 seconds. The Vickers gun, sleigh mount, and 500 rounds of ammunition were unpacked, the gun mount set up, and firing commenced in 2 minutes.

Test 4.

The Colt gun, tripod, and two ammunition boxes were dismounted and packed on the aparejo in 1½ minutes. The Vickers gun, sleigh mount, and two ammunition boxes were dismounted and packed on the Vickers saddle in 2 minutes.

Test 5.

The Colt gun, tripod, and two ammunition boxes were unpacked, carried forward 300 yards on the run by three men, set up, and firing commenced in 3¾ minutes.

The Vickers gun, sleigh mount, and two ammunition boxes were unpacked, the gun placed on the mount and carried over the same ground by two men, and two ammunition boxes by a third man, set up, and firing commenced in 4¾ minutes.

The Vickers combined carriage and tripod was unpacked from an aparejo in 2 minutes; the carriage assembled and the gun mounted thereon in 2¼ minutes; run forward over the same ground by two men, the third carrying two ammunition boxes, and firing commenced in 2¼ minutes. This was an improvised pack and the time of unpacking, 2 minutes, was greater than would be the case with a regular pack for this carriage.

The ground over which this test was made was rough, rocky, and cut by two gullies.

Test 6.

Two artillery horses were hitched to the Vickers Sons & Maxim galloping carriage, on which were placed the sleigh mount and gun, and the carriage driven over smooth roads and rough ground. As this preliminary test showed conclusively that this form of mount is not suitable for field service, further tests with it were not deemed necessary. This carriage, with its two ammunition chests, exclusive of mount, gun, and ammunition, weighs 765 pounds.

The tests made with the Colt carriage showed that it is too light for accurate firing and also that it is not suitable for field service.

Tests made with the Vickers combined carriage and tripod showed that this form of mount is not suitable for field service, but that it possesses several advantages for use around seacoast defenses.

Test 7 (9-mile march).

All marching tests were made at the gait prescribed for cavalry.

Vickers gun pack.—On one side of a Vickers saddle, altered as described under Test 1, the Vickers gun with its jacket filled with water and on the other side three ammunition boxes (750 rounds) were packed; the sleigh mount was packed on top of the metallic frame.

Colt gun pack.—On one side of the frame, placed on an aparejo, the Colt gun and loading machine were packed. The tripod was packed on the other side and four ammunition boxes (1,000 rounds) were packed on the top of the frame.

A galvanized iron tank, filled with about 12 gallons of water, was packed on a second Vickers saddle, which was not altered.

One of the steel ammunition chests, on the galloping carriage containing seven ammunition boxes (1,750 rounds), was packed on an aparejo.

A march of 9 miles was made at a walk with these four packs, with two halts. During the second halt both guns and their mounts were unpacked, the Vickers gun fired 125 and the Colt 250 rounds. The tripod used with the Colt gun this day was one sent from Rock Island Arsenal with the aparejo frame and its long leg was removable. Considerable difficulty was experienced in removing and reinserting this leg. The edges of the gun seat in the top mount were deformed. Three jams occurred in the feed mechanism of the Colt gun during the firing. The Colt gun pack rocked backward and forward during the march, due to the peculiar gait of the mule. At the end of the march all the mules were in good condition.

Throughout all the marching tests the Vickers gun pack was carried by the same mule.

Test 8 (15-mile march.)

Vickers gun pack.—The same as in Test 7.

Colt gun pack.—The same as in Test 7, except that a different mule was used.

A steel ammunition chest belonging to the galloping carriage and in which seven ammunition boxes (1,750 rounds) were placed was packed on a Vickers saddle altered as described in Test 1. The other two packs used in Test 7 were not used this day.

A march of 15 miles, 4 of which were at a trot, was made with these three packs in 3 hours and 7 minutes, including halts. After marching 13 minutes it was necessary to halt and readjust the Vickers saddle carrying the ammunition chest. At the end of the march the mules were in good condition, with the exception of the one carrying the

Vickers gun, which was slightly galled by the front cincha rubbing on the forearm. This defect was remedied by hobbling the two cinchas together at the rings. The same mule continued to carry this pack during the remaining tests, and the sore healed quickly. The clips by which the squares were attached to the ends of the metallic frame of the Vickers saddle on which the ammunition chest was packed and to the squares of which the cinchas were attached, proved too weak, three of which broke on this march.

Test 9.

First march.—This march was made with the same packs used in Test 7. The only change made was that all cinchas were removed from the Vickers saddle on which the water tank was packed and the saddle and tank held on by one canvas belly cincha 11 inches wide.

After marching one hour the water tank and ammunition packs required readjustment. Twenty miles were marched in 4 hours and 54 minutes, including three halts; 8 of the 20 miles were made at a trot. At one of the halts both guns were unpacked, the Colt gun fired 250 and the Vickers 125 rounds. At the end of the march the mules were in good condition, except that the back of the mule carrying the Colt gun on the aparejo was slightly galled on both sides on places previously injured.

Second march.—The Vickers gun pack and Colt gun pack only were used on this march. The mule on which the Colt gun was packed on the previous day was lame and a new one was used.

A march of 22 miles, 10 of which were at a trot, was made in 4 hours and 4 minutes, exclusive of halts. After marching 35 minutes the train was halted, both guns unpacked, and the Colt gun fired 250 and the Vickers 125 rounds, at an estimated range of 1,000 yards, for the purpose of determining the feasibility of picking up the point of impact by the dust raised by several shots fired automatically. The point of impact, when using the Vickers gun, was discovered. The rifling in the barrel of the Colt gun was so badly worn out that the point of impact could not be found with it. Both guns were fired at a hillside covered with tall grass. Neither of the packs were adjusted during this march. A lug on the tripod hanger of the Colt gun was found to be bent and was straightened. This piece is structurally weak. At the end of the march both mules were in good condition.

Third march.—The Vickers and Colt gun packs and the Vickers Sons & Maxim combined carriage and tripod packed on an aparejo were used on this march.

A march of 22 miles was made, of which seven were at a trot and one at a gallop. During this march tests 3, 4, and 5 were made. Part of this march was made over rough hills and down a rather precipitous and rocky slope. At the end of this march the mules were in good condition.

Test 10.

During the drills and marches the following points were determined for the pack system recommended for adoption by the board, viz:—

(*a*) A pack outfit for one automatic machine gun, tripod, the proper amount of ammunition, loading machine, spare parts, accessories, tools, water, etc., requires at least five mules.

(*b*) The five mules should be loaded as follows, viz: One mule should carry the gun, with water jacket filled, on one side; the tripod on the other side; 3 ammunition boxes or 750 cartridges on top of the frame, and an extra lock, feed block, and counter recoil spring, so placed as to balance the pack. A second mule should carry the loading machine and 7 ammunition boxes, holding 1,750 cartridges in two hangers, one attached to each side of the saddle. Each of the other mules should carry 6 ammunition boxes, holding 1,500 cartridges, and two water boxes, each holding 11 pints. Three ammunition and one water box should be carried in a hanger on each side of the saddle. The necessary number of spare barrels, locks, and other parts, tools and accessories should be distributed among the last three packs.

It is estimated that the total load carried by the first mule will, under this arrangement, be about 300 pounds, and by each of the other four about 280 pounds, the dead load in each case being about 74 pounds.

(*c*) The minimum number of enlisted men, of which a detachment for one gun, tripod and pack outfit should be composed, is six—five privates and one noncommissioned officer.

(*d*) Not less than 7,000 cartridges should and can be carried with each gun and five pack mules.

(*e*) The 7,000 rounds of ammunition carried with each gun should be loaded into belts, each holding 250 cartridges, and each belt should be carried in a wooden ammunition box of the same design as that furnished with the Vickers Sons & Maxim outfit. Ammunition should be issued to each gun detachment in the same form as that in which it is packed for issue to the arm of the service to which the gun is attached, and each detachment should, at all times, keep 7,000 rounds loaded in the belts.

(*f*) The Vickers Sons & Maxim automatic machine gun should always be packed and carried with its water-jacket filled. It requires 12 pints of water to fill the jacket. Starting with the gun cool and with the jacket filled, about 750 rounds can be automatically fired before it is necessary to replenish the water in the jacket. Thereafter it will generally be necessary to insert about 6 pints of water in the jacket at the end of every 500 rounds fired continuously. Each of the 3 mules carrying 1,500 cartridges or 6 ammunition boxes should, therefore, also carry 2 boxes of water, each holding about 11 pints. The water boxes should be of the same exterior dimensions as the ammunition boxes, be lined with copper, and provided with a large-sized screw top. Exclusive of loss by leakage, this would provide sufficient water for firing all but 750 of the 7,000 rounds carried with each gun, assuming this amount of ammunition to be fired automatically and continuously.

During the marching tests several of the ammunition boxes furnished with the Colt gun came apart or broke. They are entirely too fragile to withstand service conditions.

During the marching tests many cartridges worked loose and a number worked out of the belts furnished with the Colt gun, showing conclusively their unsuitability for service.

Before commencing the marching tests a new barrel was assembled in the Vickers standard pattern gun, during which it was fired 550 rounds.

Total number of rounds fired with this gun, 20,253.

During these tests the eroded 8-inch gun barrel was used in the Colt gun and was fired 1,200 rounds, making a total of 3,210 with this barrel and of 7,914 with the gun.

GENERAL REMARKS.

The weights of the different guns, mounts, ammunition boxes, belts or feed cases, loading machines, packs, etc., are as follows:

Articles.	Danish.	Colt	Vickers standard pattern.
	Pounds.	*Pounds.*	*Pounds.*
Gun	15.75	40	64
Tripod	24	59	51
Combined carriage and tripod			228.25
Tripod of above			86
Loading machine	11.25	14	18
Ammunition box for 250 rounds		2.25	6
Feed belt for 250 rounds		.34	2.4
Feed case for 30 cartridges	1		
Carriage, landing		176	
Sleigh mount			82.25
Spare barrel	3.25	14.25	6.25
Spare lock		.375	1.84
Spare feed block			3.75
Pack saddle, complete			74
Aparejo, frame and hangers		120	
Water required to fill jacket ... pints			12.5

GUNS.

The only guns thoroughly tested were the Colt and Vickers Sons & Maxim standard pattern, the Vickers Company having withdrawn their solid action gun, and further tests of the Danish gun being abandoned, due to the failure of the feed mechanism to operate properly. The Colt gun is designed to fire at a rate of 400 and the Vickers at 600 rounds per minute. The Vickers gun, unlike the Colt, has a water jacket for keeping the barrel cool. The barrels of both these guns are about 28 inches in length and their velocities at 53 feet differ only by 10 feet per second. The two guns appear to be equally accurate at 500 and 1,000 yards. The mount of the Colt gun, however, was less stable, requiring more frequent adjustments of aim. The endurance of the Vickers gun, when the jacket is kept filled with water, is greatly superior to that of the Colt. The Colt gun was fired 2,302 rounds with the first 10-inch twist barrel prior to the endurance test, during which 999 rounds were fired in 3 minutes and 41 seconds, and one hour thereafter 1,372 rounds were fired in 6 minutes and 50 seconds, when the accuracy of the barrel was completely destroyed.

From a second barrel rifled with one turn in 8 inches, after being fired 150 rounds, 1,046 rounds were fired in 5 minutes and 29 seconds, when its accuracy was also completely destroyed.

From a third barrel, rifled with one turn in 10 inches, after being fired 270 rounds, 1,318 rounds were fired in 9 minutes, when its accuracy was also completely destroyed.

These tests show that the accuracy of the barrel of this gun will be destroyed by firing about 1,000 continuous rounds.

The first barrel in the Vickers gun was fired 1,889 rounds prior to the endurance test. During the first series it was fired 587 rounds in

2 minutes and 4 seconds and then 1,000 rounds in 3 minutes and 2 seconds. One hour thereafter it was fired 2,000 rounds in 11 minutes and 42 seconds. After cooling, the third series of 3,000 rounds were fired in 22 minutes and 45 seconds; 355 rounds were afterwards fired to test the accuracy of the barrel, and then 3,620 rounds were fired in 40 minutes and 15 seconds, when its accuracy was destroyed.

A new barrel was then assembled in the gun and 5,864 rounds fired in 45 minutes and 20 seconds, when its accuracy was found to be impaired, though it still gave good results at 500 yards range.

A third barrel was assembled in the gun and fired 250 rounds with the jacket filled, after which the water was removed and 547 rounds fired in 6 minutes, which completely destroyed the barrel.

These tests show the necessity for cooling the barrel by water and also that the Vickers gun should never be fired except in extreme emergency without water in the jacket.

The Vickers gun stood the dust and defective-cartridge tests much better than the Colt. Both guns passed through the excessive pressure, decreased and increased pressure, and the rust tests satisfactorily, neither showing superiority over the other.

The radiation of heat from the Colt barrel seriously interferes with sighting after a few hundred rounds are fired from it. After 500 to 1,000 rounds are fired continuously from the Colt gun, the heat remaining in the barrel is sufficient to ignite a cartridge in the chamber, which is not the case with the Vickers gun. The gas lever handle on the Colt gun also becomes so heated as to burn the hands, and as this lever must be operated to insert each belt, this is a serious defect. After firing about 500 rounds the Colt gun becomes so hot that it can be handled only with great difficulty.

By taking the actual time required to fire the 125 cartridges in a belt, the rate of fire of the Vickers standard gun was found to be 652 shots per minute, with a new barrel, about 534 shots per minute after the barrel was somewhat eroded and the lands of the rifling worn, and 326 per minute during the firing of the last belt in the series of 3,000 rounds of Test 13. In long continuous firing with the Vickers gun, the highest average rate obtained was 320 shots per minute during the first series of 1,000 rounds. This average rate reduced to 171 for the 2,000, 131 for the 3,000, and 90 for the 3,620 rounds of Test 13, all of which were fired with the same barrel. With the second barrel used in this gun, 5,864 continuous rounds were fired at the average rate of 129 shots per minute.

With a new barrel, the rate of fire with the Colt gun was 480 shots per minute, and as the bore was eroded, the lands worn out, and the temper of the retracting springs drawn, this rate decreased to about one-half. In long continuous firing with the Colt gun the average rate of fire during the first series of 1,000 was 270 shots per minute, and during the 1,372 rounds of the second series of Test 13, was 200 per minute. The average rate with the second barrel used in this gun for 1,046 rounds was 190, and with the third barrel for 1,318 rounds, 146 shots per minute.

Although the Vickers gun is designed to have a higher rate of fire, the belts used in it held 125 instead of 250 cartridges, as in the Colt. The time required to insert a belt in either of these guns and to load it is about 10 seconds.

During the tests the following parts broke in each gun, viz:

Vickers: Two link pins, counter-recoil spring, feed-pawl spring, and gib spring. The lock was changed several times because the firing pin did not strike the primer.

Colt, extractor: The temper was drawn from three sets of retracting springs and a longer firing pin was inserted.

The feed belts of the Colt gun will not properly hold the cartridges when jostled on the march or after the belts have been wet; they stretch unevenly and cause cartridges to be caught by the cogs on the feed wheel, by which they are deformed and the firing stopped.

During the test of the Colt gun 4,704 rounds were fired with the first barrel, 3,210 with the second, and 1,588 with the third, or a total of 9,502 rounds with the gun.

During the tests of the Vickers standard pattern gun 13,839 rounds were fired with the first barrel, 5,864 with the second, 550 with the third, and 797 with the fourth, or a total of 21,050 with the gun.

The ammunition boxes with the Colt gun are entirely too fragile for field service.

The tripod proper of the Colt gun is serviceable and stable, but the top mount is unsatisfactory, due to the back lash in the worm and rack, the failure of the clamps to firmly lock the gun in azimuth and elevation, and the uncertainty of the oscillation clamp.

The Vickers tripod mount is unstable, the top carriage is too loose on the tripod, and the clamp on the elevating mechanism can not be quickly operated. The feature by which the front legs can be locked parallel to the rear one, to enable the tripod and gun to be carried, is excellent.

The combined carriage and tripod is too heavy and bulky to pack for field service, but possesses excellent features for use around seacoast defenses. The tripod with this carriage is more suited to field service than the other tripods tested, but its rear leg in its present form is too long to conveniently pack, its weight slightly too great, and the lunette, the handle bar and its socket are unnecessary.

The sleigh mount is too bulky to balance the gun as a side pack, is awkward to adjust, heavy, and can not be adjusted to accommodate itself to uneven ground.

The galloping carriage is entirely too heavy and cumbersome for field service.

The field tests made show that either the aparejo with its frame or the Vickers saddle is suitable for field service. In view, however, of the experience required to properly handle the aparejo and its greater weight, the Vickers saddle is better suited for use in packing material of this character.

The Vickers loading machine is stronger, simpler in design and operation and more serviceable than the Colt machine. Several of the needles in the latter were broken.

RECOMMENDATIONS.

Gun.—The Vickers Sons & Maxim standard pattern automatic machine gun should be modified as follows, viz: The counter-recoil spring should be worked in compression, instead of in extension.

Provision should be made whereby the tension of the counter-recoil spring can be more easily adjusted and an indicator provided to show the amount of its tension.

The fusee link pin should be strengthened.

The screw covers for the oil cups in the handles should be secured so they will not be unscrewed by the vibration due to firing.

The rear sight should not be graduated for ranges greater than 2,000 yards.

An effort should be made to reduce the size of the muzzle attachment.

Tripod.—None of the tripods tested were found to be satisfactory for field service. The one on the Vickers combined carriage and tripod, however, proved to be the best. This tripod should be modified as follows, viz: The front legs should be provided with slots and the pintle bracket with lugs, so that the front legs can be fixed parallel to the rear one for carrying the gun and tripod as can be done with the Vickers light tripod.

The lunette, wooden maneuver bar and its socket should be omitted from the shoe plate on the rear end of the long leg. The steel points in the shoe plate of all three legs should be larger and longer. The rear leg should be made in two parts, hinged together under the seat bracket, so that the rear part can be turned forward to shorten it for packing. The pintle bracket should be lightened and the axle seat omitted. The present azimuth clamping device should be replaced by an azimuth screw of small pitch.

The weight of the tripod should be reduced to that of the gun with the water jacket filled to insure a properly balanced pack.

Combined carriage and tripod.—This carriage, as submitted by the Vickers Sons & Maxim, is in the main well adapted for use in and around seacoast defenses. The tripod should be the same as that recommended for use in field service, except that the rear leg should be made in one piece and the pintle bracket provided with a seat for attaching it to the axle. The wheels and axle should be much lighter, the wheels reduced in diameter, and the tires widened. A bracket should be attached to the axle on each side of the tripod, on which three ammunition boxes can be carried.

Ammunition belts.—The Vickers belts proved satisfactory, but should be made to hold 250 rounds.

Ammunition and water boxes.—The Vickers boxes proved serviceable and convenient. Boxes of the same exterior dimension, lined with copper and provided with a large-sized screw-cover, should be furnished for carrying water.

The copper cup with its valve for filling the jacket is satisfactory.

Loading machine.—The Vickers loading machine is serviceable and satisfactory in all respects.

Pack saddles.—The top frame of the Vickers saddle should be made of such dimensions as to hold three ammunition boxes, each holding 250 cartridges, standing on their bottoms. Angle irons should be provided on the ends as well as on the sides of the frame. Steel loops should be attached to both sides and ends of the frame to enable the three ammunition boxes to be lashed in place. The middle square on each side bar should be omitted and the outer two and their clips made stronger. Two cavalry saddle cinchas should be used for cinching each saddle to the mule and be attached as follows, viz: The upper end of the link strap should be permanently fastened to each square and the lower end passed through a 4-inch ring and secured to the link by a buckle so as to permit adjustment in the distance of the ring from the side bar. One hair cincha should be attached by rawhide cincha straps to the two front and the other to the two rear 4-inch rings on each side. The two rings on each side should be hobbled together and the two cinchas connected under the mule's belly by a light strap. The hand-holes under the side bars should be made larger to admit of easier manipulation of the hair in the pad.

The flannel lining of the pad should be replaced by light duck, which is more durable and serviceable than the former.

The crupper, instead of being connected as at present to the top of the frame, should be connected by a split back-strap to rings on the upper rear corners of the pads. The side and back-straps should be more strongly attached to the ends of the breech and breast straps and both of the latter lengthened to fit the larger mules in our service.

A saddle blanket should be issued in place of the felt saddle pad, as with the former the load is less liable to slip. The blanket can be unfolded to shake out and dry. When the felt pad is worn thin in places, as will occur, it becomes useless.

A duck boot should be secured to the gun hanger to protect the gun from dust and rain.

FINDINGS.

As a result of the tests made with the material submitted to it, the board, in accordance with instructions contained in the convening order, finds as follows, viz:

First. That the Vickers Sons & Maxim standard pattern automatic machine gun is best adapted to fulfill the requirements of the military service. The modifications suggested herein should, however, be embodied in this gun.

Second. That the tripod on the Vickers Sons & Maxim combined carriage and tripod, and the Vickers Sons & Maxim pack saddle, when both are modified as recommended herein, are best adapted for our field service; and, also, that the Vickers Sons & Maxim combined carriage and tripod is best adapted for use in and around seacoast defenses.

Third. That the most convenient and serviceable form in which ammunition for automatic machine guns can be carried in field service is in feed belts, each holding 250 rounds; that each belt should be packed in a wooden ammunition box of the same design as that furnished by the Vickers Sons & Maxim Company, and that these boxes should be transported on pack saddles. The ammunition for these guns should be issued to each gun detachment in the same form as issued to the troops with which the detachment is serving. A Vickers Sons & Maxim loading machine should be carried with each gun and each detachment should at all times keep 7,000 rounds of ammunition loaded in belts.

Fourth. That for field service pack transportation should be provided for 7,000 rounds of ammunition for each gun; that the gun, tripod, three ammunition boxes, spare lock, feed block, and counter-recoil spring should be packed on one mule; that seven ammunition boxes and the loading machine boxed, should be placed on a second mule; that six ammunition boxes and two water boxes should be packed on each of the other three mules and that the additional spare parts, accessories, tools, and water cup be distributed among the last three mules; that six ammunition boxes should be packed on the axle of the combined carriage and tripod recommended for use in and around seacoast defenses.

The board recommends that the material enumerated above, found, as the results of the tests made, to be best adapted to fulfill the requirements of the military service, be adopted.

There being no further business before the board, it adjourned sine die.

EDWIN V. BOOKMILLER,
Captain and Adjutant, Ninth Infantry, President.
T. C. DICKSON,
Captain, Ordnance Department, Member and Recorder.
JNO. S. WINN,
Captain, Second Cavalry, Member.
GEO. D. GUYER,
Captain, Sixteenth Infantry, Member.
W. S. MCNAIR,
Captain, Artillery Corps, Member.

Descriptions of material tested.

(With 15 plates.)

Plate 1, Danish rifle-mitrailleuse.
Plate 2, Danish rifle mounted on tripod.
Plate 3, Danish rifle being fired in prone position.
Plate 4, Colt gun.
Plate 5, Colt loading machine.
Plate 6, Colt gun mounted on tripod.
Plates 7 and 8, Vickers Sons & Maxim solid action gun.
Plates 9 and 10, Vickers Sons & Maxim standard pattern gun.
Plate 11, Vickers Sons & Maxim loading machine.
Plate 12, Vickers Sons & Maxim combined carriage and tripod.
Plate 13, Vickers Sons & Maxim tripod.
Plate 14, frame for packing Colt gun and tripod on aparejo.
Plate 15, Vickers Sons & Maxim pack saddle.

DESCRIPTION OF THE DANISH RIFLE-MITRAILLEUSE.

Figure 1, on Plate 1, shows a cross section of this rifle and an elevation of the tripod arms. Figures 2 and 3 show cross sections on the lines C——D and G——H, respectively.

Plate 2 shows the gun mounted on the tripod, and Plate 3 the gun being fired prone with the muzzle-rest device.

The barrel cover (1) is screwed into the frame (2) and in rear of the muzzle two legs (3) are attached to the barrel cover for supporting the rifle when it is fired in the prone position. When these legs are not in use they can be turned back along the under side of the barrel cover.

The receiver (4) is screwed onto the barrel (5); the breechblock, extractor, hammer, and cartridge feeder are assembled to the receiver.

The barrel, receiver, and the parts assembled thereto move longitudinally in the barrel cover and frame.

The mechanism is operated by the energy of recoil of the barrel and the parts attached thereto, which energy is produced by the powder pressure in the bore and by the reaction of the powder gases on the muzzle. The rifle submitted for test differs slightly from that shown on Plate 1, in that the muzzle cover extended forward $1\frac{3}{8}$ inches beyond the barrel and was closed with a plug containing a hole slightly larger in diameter than that of the bullet. The object of the space thus formed between the end of the barrel and the plug is to increase the energy of recoil of the moving parts by means of the reaction of the powder gases on the muzzle during the time elapsing from the instant the bullet leaves the barrel until it has passed the plug.

The head (6) of the recoil arm (7) and that of the percussion arm (8) bear against the plug (9) which is dovetailed into the rear wall of the receiver; the recoil arm (7) is assembled on the square section (10) of the operating bolt (11) so that the bolt and arm rotate together. The percussion arm (8) is assembled on the round section of the operating bolt (11) and its movement is, therefore, independent of that of the bolt. The recoil and the percussion arms are actuated by the counter-recoil spring (12) and the percussion spring (13), respectively. On the right-hand side of the plug (9) is a lever (14), on which the head (6) of the recoil arm slides when the breechblock is opened by means of the handle (15) assembled on the right end of the operating bolt (11). The handle (15) is assembled to the operating bolt (11) in such a manner that it does not rotate with the bolt when the piece is fired.

The hammer (16) is assembled on the left side of the plug (9); when the piece is fired the percussion arm strikes the hammer and transmits its blow to the firing pin (17).

The breechblock is pivoted in and near the rear end of the receiver (4) and the cartridge feeder (18) is pivoted between two lugs projecting from the under side of the receiver.

The upper end of the cartridge feeder (18) is curved and its lower end has two arms (19), which, during the forward and backward movements of the recoiling parts, bear against a block (20) fixed in the trigger plate (48). During the rearward movement of the receiver the upper end of the cartridge feeder is moved to the rear and engages the cartridge in the hopper, and during the forward movement of the barrel the cartridge feeder is moved to the front, thereby forcing the cartridge forward into the chamber. On the right side near the front end of the breechblock is a guiding pin (22); the upper left side of the breechblock is shaped so as to guide the cartridge while it is being inserted in the chamber by the cartridge feeder. On the under side of the block is a curved surface (23) for guiding the empty shell during its ejection; the firing pin (17) is seated in a longitudinal hole in the breechblock and its movements are limited by the screw (24). The firing pin is provided with a spring to hold its point within the face of the block.

The breechblock is rotated vertically in the receiver by the guiding pin (22) which, during the longitudinal motion of the receiver, moves around the prismatic lug (25) and the irregular curve (22) formed in a side plate which closes an opening in the right side of the frame.

The ejecting mechanism consists of the block (27) pivoted to the receiver, of the ejector (30) pivoted in the block, and of the springs

(28 and 29). During the rearward movement of the barrel and receiver the ejector pin, which is moved downward by the cam lugs, and a plate closing an opening in the left side of the frame, prevents the ejector mechanism from releasing the cartridge before the lower end of the ejector strikes against the lever (31), whereby the upper end of the ejector is thrown to the rear, thereby ejecting the empty shell. To prevent the ejector from interfering with the insertion of a cartridge in the chamber the front end of the breechblock (21) bears against the rear end of the block (27) during the forward movement of the receiver and holds the ejector (30) below the chamber until the cartridge is inserted and the front end of the breechblock raised into position.

The trigger (31) is pivoted in the guard and in its front end is hinged a hook (32) which passes through a slot in the sear (33). Under the action of the sear spring (34) the sear is engaged by the hook. The rear end of the sear is pivoted in the guard; on its top is a lug (35) which engages in the sear notch of the percussion arm (8) and holds the latter in its cocked position. On the right side of the sear is a seat for the block (36) which is actuated by the lug (37) on the trigger (31), so that the block is moved forward when the trigger is pulled. When the trigger is pulled its front end is depressed against the action of the trigger spring, and the hook, and consequently the sear, are moved downward until the lug (35) is disengaged from the percussion arm (8), leaving the latter free to rotate under the action of the spring (13) around the bolt (11).

In order to prevent accidental discharge, when the breechblock is not fully closed the front sides of the hooks of the percussion and recoil arms are slightly flattened, forming a recess for the upper end of the hook (32), in which it must be seated before it can engage and depress the sear. As this recess in the hubs of the arms is so located that the hook (32) can enter it only when the breechblock is fully closed, the gun can not be fired until this condition exists.

To fire automatically the swivel (38) should be turned so that the trigger can be pulled completely back. When this is done the block (36) is pushed so far forward by the arm (37) that the lug (39) on the hub of the recoil arm presses the block (36) and with it the sear (33) each time the block is closed, thereby releasing the percussion arm and firing the piece. When the trigger is released the arm (37) raises the block (36) so that the lug (35) on the sear can engage the percussion arm and stop the firing. The safety lock (40) has a lug (41) which can be turned beneath the front end of the sear (33) so that the trigger can not be pulled. The handle of the safety lock is on the left side of the trigger plate. On the left-hand side of the frame (2) is a hopper (42) into which a feed case can be inserted and locked therein by means of the lever (43). In the exterior wall of the hopper (42) is the stopping hook (44) which catches the receiver in its rearmost position when the last cartridge in the feed case has been fired, and retains the receiver in this position until the hook is released by the insertion of another case. The stopping hook turns round the pin (45) and is actuated by the spring (46). A projection from the top of the frame receives the cartridge feeder and the remainder of the top is closed by the cover (47). The bottom and rear ends of the frame are closed by the trigger plate (48), the front end of which terminates in two hooks (49) which engage in slots in the frame and at the rear by the screw (50) which passes through the side walls of the frame (2) and also through those of the trigger plate.

On the under side of the trigger plate is an opening through which the empty shells are ejected. This opening is closed by the gate (51) which, when the rifle is used in the tripod, serves as an elevating arm. The operation of this rifle is as follows:

When fired the pressure exerted by the powder gases upon the breechblock and the reaction of the gases on the muzzle of the barrel move the barrel, receiver, and parts attached thereto rearward, thereby rotating the recoil and percussion arms about the operating bolt, compressing their respective springs and engaging the percussion arm with the sear. The moving parts are returned to their firing position by the recoil spring actuating the recoil arm. During the rearward motion of the barrel and receiver the front end of the breechblock is rotated upward to permit the extraction and ejection of the empty shell, and during their forward motion the front end is first rotated downward so as to permit the insertion of the cartridge and then upward against the head of the cartridge. During the rearward motion of the barrel and receiver the ejector is tripped in such a manner as to extract the empty shell from the chamber and throw it against the curved surface on the under side of the bolt by which it is directed out of the gun. During the rearward motion of the receiver the upper end of the cartridge feeder is rotated rearward so as to engage the head of the lowest cartridge in the hopper, and during the forward motion of the receiver it is rotated forward in such a way as to insert the cartridge in the chamber. If the point of the swivel (38) is turned downward in the guard bow and the trigger pulled, one shot will be fired, loaded, and the piece remain cocked; if the point of the swivel be turned upward out of the bow, automatic firing will continue as long as the trigger is held back. The feed guide forms the magazine of this gun and is inserted in the hopper on the left side of the frame.

The feed case is made of tin and is circular in shape. One end of a ribbon spring is attached to its upper end, and to the other end of the spring is attached the follower. On the lower front end of the case is a lug to be engaged in a slot in the front end of the hopper, and on the rear end is a notch in which the lower end of the lever (43) engages to secure the case in the hopper. On the lower outer side of the feed case is a spring which retains the cartridges therein and which, when the case is inserted in the hopper, is sprung outward by a beveled surface in the left wall of the hopper, thereby permitting the passage of the cartridges from the feed guide into the hopper. The feed case holds 30 rounds.

The loading machine consists of a semicircular metal trough, in which a feed case and 30 cartridges are placed. The cartridge section has a hinged cover to prevent their displacement. The cartridges are forced into the feed case by a lever pivoted to an arm attached to the ends of the trough.

The tripod has three legs of tubing pivoted in a block. The lower end of each leg is pointed and has a plate hinged to it to limit the distance which it can be inserted in the ground. The rear leg is curved, has a brace, and is provided with an adjustable bicycle seat. The pintle can be turned sideways on the block by means of a screw to level the gun. The pintle can be moved in azimuth in the pintle socket. The top carriage can also be rotated sideways in the pintle. It has two arms in which the gun is trunnioned, and at the rear end a slot into which the bottom cover on the gun can be clamped by a screw.

DESCRIPTION OF THE COLT AUTOMATIC MACHINE GUN, MODEL OF 1903.

Plate 4 is a top view and side elevation of the gun, showing the breech closed. The numbers in the following description refer to the corresponding numbers on this plate. In its construction this gun differs from the model of 1899 only in that the short retracting connection link is made solid instead of in two parts, and the addition of the belt guide lock-screw and of the barrel-lock pin. The barrel is screwed into and secured in the receiver by the barrel-lock pin, and this method of assembling enables the barrel to be easily replaced. The parts of the operating, firing, and feeding mechanisms are assembled to the barrel and receiver, and are inclosed by two side plates and the bottom plate, which are secured to the receiver and gas-lever bracket.

The automatic action of the piece is effected by means of the pressure of the powder gases in the bore. When the bullet is about 7 inches from the muzzle a hole opening vertically downward from the bore into the gas cylinder is uncovered and the action of the powder gas escaping through this hole upon the piston, pivoted on the front end of the gas lever, is used to open the breechblock, extract and eject the empty shell, cock the hammer, withdraw from the belt, and deliver in front of the breech bolt a cartridge, and to compress the retracting springs. The energy thus stored in the springs is used to insert the cartridge in the chamber, close and lock the breech bolt, revolve the feed wheel, and return the operating parts to their firing positions.

The radial vent in the barrel is .067 inch in diameter and opens into the gas cylinder, which is closed by the piston (35). The piston is pivoted on the front end of the gas lever (29), the rear end of which is pivoted in the gas-lever bracket (33) on the gas-lever bracket pin (34) so as to swing thereon in a vertical plane below the barrel. Two tubes (39 and 40), immediately beneath the barrel, contain springs (37 and 38) which are connected by the retracting connection (45) and links (47 and 49) to the short arm of the gas lever (29) in such a manner that the springs yieldingly hold the gas lever in position, as shown in the drawing, with the piston closing the vent. The gas-lever connection (31) is pivoted at its front end to the gas lever by the gas-lever connection pin (32) and at its rear end with the slide (86) by the slide pin (87). The slide has a longitudinal motion under the barrel and in its recesses in the receiver, and at its rear end is connected with the breech bolt (13). The breech bolt is arranged so as to move backward and forward in opening and closing the barrel. When closed the rear end of the breech bolt is swung downward, turning on the front end as a fulcrum, and in this position it is supported by abutments in the receiver. A central rib of the breech bolt projects into a slot in the rear end of the slide and the pin (14) passes through the slide and through the diagonal slot in this rib, thus connecting the breech bolt with the slide and causing the latter as it moves rearward, first, to raise the end of the breech bolt, thereby unlocking it, then to move it rearward and open the breech; the forward movement of the slide moves the breech bolt forward and finally forces its rear end down, thus closing and locking the bolt. In rear of the breech bolt a hammer (6) is arranged, the stem of which and the mainspring (7) in it are guided in the handle (1), which closes the rear end of the receiver, and to which the trigger (8) and sear (10) are attached. This hammer is also used as a piston for the air pump which forces a strong jet of air into the chamber and removes all particles of unburned powder immediately after the empty shell is extracted. As the bolt moves rearward it forces back the hammer. The trigger (8) and sear (10) serve to retain the hammer cocked until the breech bolt is closed and locked, when the hammer may be released by pulling the trigger. The trip (85) is pivoted in the left side of the receiver and when the breech bolt is closed the slide raises the front end of the trip, thereby causing its rear end to disengage the sear from the hammer. If the trigger is then pulled the piece will be fired. If the pull on the trigger be continued the trip will cause the sear to release the hammer the instant the breech bolt is fully closed on each cartridge and the piece will be fired automatically. By this means either single shots or a continuous volley may be fired. This gun is designed so as to fire automatically at the rate of 400 rounds per minute.

The feed belt is inserted through an opening in the left side of the gun and the cartridges in it pass successively over the feed wheel (61), which is rotated by the slide (86) and the levers (66 and 71), so that at each stroke of the slide one cartridge is presented in front of the extractor (82) attached to the slide, and by it the cartridge is drawn rearward onto the carrier (21), pivoted at (22) in the receiver. The empty feed belt passes through an opening in the right side of the gun. A dog (63) is attached to the bottom plate (91), which prevents the feed wheel from rotating in the wrong direction. A feed throw-off (68) is pivoted on the right side of the gun, by which the feed-wheel dog can be disengaged from the feed wheel to permit withdrawal of a partially emptied belt. The rear end of the carrier is provided with a spring dog (23) which yields to the slide in its rearward movement but causes the first part of the forward movement of the slide to raise the front end of the carrier and present the cartridge thereon in front of the breech bolt, by which it is pushed into the barrel. The shell extractor (15) is inserted in the right side of the breech bolt and withdraws the empty cartridge shell from the chamber and retains it in the recess in the front end of the bolt until the shell is struck by the ejector (76) and thrown out of the gun through the opening on the right-hand side of the receiver. The firing pin (18) in the breech bolt, so located that it can be struck by the hammer only when the breech bolt is firmly locked, transmits the blow from the hammer to the cartridge primer.

A safety lock (58) securely locks the hammer and prevents the firing pin from being struck when its outer arm is turned to the position marked "Safe." The safety lock is to be used only when a loaded cartridge is left in the chamber.

The cartridges can be loaded by a machine into the belt, one end of which is inserted from the left through the belt openings in the side plates, the right end of the belt is pulled so as to bring a cartridge in front of the extractor and the gas lever is then swung downward and to the rear by hand and released. The gun will then be loaded.

When fired the action of the parts is as follows, viz: When the trigger is pulled the hammer is released and is thrown forward by the mainspring, so that it strikes the firing pin, which in turn strikes the primer and ignites the cartridge. As soon as the bullet has passed the vent, the gas lever is rotated about 180 degrees downward and to the rear, thereby compressing the retracting springs and moving the slide to the rear. During this rearward motion of the slide, the rear end of the breech bolt is raised and the bolt, together with the hammer, is moved rearward until the latter is caught by the sear and trigger; the empty shell is withdrawn from the chamber by the extractor and thrown out of the gun by the ejector, a cartridge is withdrawn from the belt onto the carrier by the cartridge extractor, and the feed lever (66) causes the pall of the ratchet lever to ride upward over the cam surface on the next tooth of the feed wheel. When the rotation of the gas lever to the rear stops, the retracting springs being compressed return the gas lever to its firing position. During the forward movement thus communicated to the slide, the feed wheel is rotated so as to bring the next cartridge in front of the cartridge extractor, the carrier is raised, the breech bolt moved forward, forcing the cartridge on the carrier into the chamber, and is locked, and the sear is released from the hammer by the trip, leaving the piece loaded and cocked ready for firing.

Each feed belt consists of a single piece of cotton duck woven with loops, into which cartridges are inserted. A brass strip is riveted to each end of the belt. The belts used in the tests held 250 rounds, but can be made any desired length.

Each belt is placed in a wooden box having a sliding lid. Near one end of the box, that is specially shaped, are two grooves by which it is attached to the mount.

The belt-loading machine, Plate 5, is arranged so that single cartridges packed in pasteboard boxes, or cartridges packed in clips of five, can be loaded directly into the belt. The first two cartridges must be inserted in the belt by hand, which is then inserted and locked in the machine with the first cartridge in the feed wheels. Turning the crank causes the cartridges to be successively inserted in the loops of the belt. The machine can be attached to a bench, box, etc., by two screws. This machine can be operated by one man, but the rate of loading is practically doubled when operated by two.

The mount consists principally of two bronze castings. The upper one contains the seat for the gun, in which it is secured by a pin, and beneath this seat is a semicircular rack engaging an elevating worm. A screw is provided in the seat by which any vertical lost motion of the gun therein can be prevented. This part is provided on the left side with a seat for the ammunition box and is trunnioned on a bolt on the lower part. The lower part is provided with two trunnion arms attached to a flanged, conical pintle, by which the mount is assembled to the carriage or tripod so as to have a motion in azimuth. An elevating shaft, carrying a worm and handwheel, is assembled in the lower part beneath the elevating rack. A clamp screw is provided for locking the mount in elevation. The lower part is secured to the tripod or carriage by a friction disk and screw bolt.

The tripod consists of three legs pivoted to a bronze casting, which forms a pintle socket for the mount. The legs are made of steel tubing, one being somewhat longer than the other two. Their upper ends are provided with bronze hinge pieces and their lower with bronze shoes and pointed steel pins. A clamp screw is provided for locking the mount in azimuth. A bicycle saddle and leather case for tools, spare parts, etc., are attached to the long leg. An oscillating arm can be attached to the mount in place of the friction disk, and in each fork of the rear end of the arm is a clamp screw. A lug is attached to the long leg and the clamp screw can be adjusted so as to limit the arc through which the gun can be oscillated or to prevent its oscillation. The gun mounted on this tripod is shown on Plate 6.

The carriage consists of a tubular axle and trail united by a bronze pintle socket, to which the mount is assembled. The rear end of the trail is provided with a shoe, a steel point, and a socket for a wooden bar by which two men can maneuver the cartridge. The wheels are 36½ inches in diameter, have wooden spokes, felloes, and hubs, and 1⅜-inch tires. A bicycle seat and leather case for tools, etc., are attached to the trail. A clamp screw in the pintle socket enables the gun to be locked in azimuth. Two brackets are secured to the axle, to which two chests are fastened; the front one holds two and the rear one six ammunition boxes, each holding 250 rounds.

DESCRIPTION OF THE VICKERS SONS AND MAXIM SOLID ACTION MACHINE GUN.

Figures 1, 2, and 3 of Plate 7 are respectively a side elevation, longitudinal cross section and a plan view of this gun. On Plate 8 are two longitudinal sections of the recoiling parts, Figure 4 showing the lock closed, and Figure 5 the lock open. The numbers of the parts in this description correspond to those on the drawings.

The energy required for the automatic operation of this gun is derived from the action of the powder gases, as they escape from the muzzle of the barrel, upon a piston.

The water jacket (30), of steel, holds about 12 pints of water for keeping the barrel cool during firing; it has 3 openings, one on the upper right side near the breech for filling, one underneath near the muzzle for drawing off the water, and the third, also near the muzzle, for the escape of steam. The first two are closed with screwed plugs (33) and (34) the last (41) by a rubber plug.

To prevent the escape of water, there is at the forward end of the water jacket asbestos packing which is held in position round the barrel (25) by the muzzle packing gland (32). Near the rear end of the barrel (25) are two cannelures (91), also filled with asbestos packing, to prevent water leaking into the mechanism.

In front of the water jacket is a gas chamber (42) inside of which a piston (43) works. The latter has a hole in it through which the bullet passes after leaving the barrel.

On the upper surface of the gas chamber is a lug, to which the front sight (102) is attached, and on each side are guides (103) for the yoke (44). Underneath the water jacket are two guide lugs (46) which control the motion of the action bar. The piston is secured to the yoke (44), the rear ends of which are connected to the action bar (48) by the joint pin (47). The action bar is forked, the right-hand arm is prolonged into the breech so as to engage with the action lever (51), and the left arm has a slot cut in it which works the feed lever (59); each arm has a trunnion bearing in which engage the trunnions of the action bar spring casing (50). The front end of the spring casing engages in a recess in the trunnion block. This casing consists of two cylinders, the rear one sliding over the front one, and inside is a spring (49) called the action-bar spring.

Under the water jacket is the ejector tube (26), through which the empty cartridge cases are ejected from the gun; the spring (27) prevents these cases falling backward into the casing.

A steam tube is fitted in the water jacket above the barrel, consisting of two tubes, one fixed, having a hole near each end, the other arranged to slide freely on its exterior and termed the slide valve. If the gun is fired at an elevation, this valve slides backward, closing up the hole at rear end of tube, and prevents water entering; at the same time it leaves the front hole uncovered, which, being above the water level, allows the steam to enter the fixed tube and to escape through the hole bored in the solid part of the front end of the water jacket, with which the tube is connected. Similarly if the gun is fired at a depression the valve slides forward, uncovers the rear hole, allowing the steam but not the water to escape.

The breech casing is attached to the mount by means of the cross-head and elevating joint pins, and consists of two outside plates (67), a bottom plate (88), and the handle block (79), the whole being closed by a cover.

The outside plates are dovetailed into the water jacket, and together with the cover are secured by means of the cover joint pin (92). In both plates are slots which enable the crank, recoil plates, and barrel to be inserted in the gun. On the inside of both are solid cams (73), which control the path of the carrier. On the outside of the right-hand plate are the following fittings, viz:

Buffer spring socket (72), which forms a stop for the action lever, and contains a recess which receives the buffer spring (71); stud (52) on which fits the action lever (51) which is secured to it by means of a collar (53) and a split pin; a projection (70) which forms the crank-handle stop.

On the outside of the left-hand plate are three studs (78) for the clock spring box (75) and a boss through which passes the axis screw (60) of the feed lever. At the rear bottom end of both plates are holes through which passes the handle block joint pin (86) on which the handle block (79) is hinged.

The bottom plate (86) is secured by rivets to the two outside plates; along the bottom lies the trigger bar (82) and underneath is a bracket (89) to which the elevating gear is attached by means of the elevating joint pin.

The outside plates are connected at the rear end by the handle block (79) which is held in position by means of the taper pin (87). The handle block is fitted with hollow handles for traversing, which are also used for carrying oil, a firing lever, the lower end of which is attached to the trigger bar, while its upper end is provided with a push button (83) for firing and a safety indicator (85) which is so arranged that when it is turned to the safe position the firing button can not be pressed forward.

The cover is fitted with cam guides (93) to insure the carrier dropping on recoil. At the rear end is a gun-metal block (94) to keep the lock down when in its rearmost position. In this block is a recess in which the cover catch (95) with spring (96) and plunger (96a) fit. On the upper surface of the cover is the tangent sight, which is graduated to 2,000 yards.

Inside the breech casing are two recoil plates (24); these are each provided in front with a trunnion hole, which receive the barrel trunnions and inside each are grooves (105) in which the flanges of the lock move. In addition, each has a hole which forms a bearing, through which the crank passes. On the inside of the right recoil plate is the carrier holding-up spring. On the outside of both plates are projections, which accurately fit in slots in the casing plates.

The breech end of the barrel (25) is formed in the shape of a block, having a trunnion on each side, by means of which the barrel is attached to the recoil plates.

The crank (22) is fitted on the right end with a handle (69), the left is square to receive the clock square (77). The crank pin works in a slot in the lock casing to which it communicates a reciprocating motion. In front of the crank pin are two horns (22a), which engage with the corresponding projections on the lifting lever (15), by means of which the carrier is raised to the firing position.

On the left of the breech casing there is a strong spiral spring (74) called the clock spring, one end of which is attached by a hook (77a) to the clock spring square (77) and the other end to the hook (76) in the clock-spring box.

The crank pin works in slots in the lock casing, and then in the firing position closes the breech. The lock is kept in position during its backward and forward movements by means of flanges working in the grooves (105) in the recoil plates and also by the gun metal block (87).

The carrier (17) is attached to the front end of the lock by guide ribs upon which it has a vertical motion and is fitted with tail spring (21), gib (18), gib spring (19), and shutter (20). The projections on the tail spring and gib, together with the cartridge grooves in the carrier, retain the cartridges in position.

The carrier is now moved upward by means of the lifting levers (15) and the crank horns (22a), and when in its highest position is retained there by means of the carrier holding-up spring which insures the hole for the firing pin being opposite the primer of the cartridge. The upward and downward movements of the carrier are regulated by guide ribs and stops, the upper stops forms part of the lock casing and the lower one (13) is removable.

The gun is supplied with cartridges from a belt which passes through the feed block, on the top of the gun, from right to left. This belt is formed by two pieces of flax webbing united by eyelets and brass strips between adjacent cartridges; the projecting ones guide the belt through the feed block and securely locate the belts in the ammunition boxes. The belt is made thick at the edges next the bullets by being folded over a piece of cord, so that the cartridges may be kept parallel in passing through the feed block.

The feed block (54) is provided with a slide (55) to which is attached the pawl (61) with a spring for the purpose of moving the cartridges from right to left. The slide has a transverse motion given to it by means of two levers, which are fitted together. The top lever (56) has a slot which engages a stud on the slide, while at the end of the bottom lever (58) is a stud which engages in a recess in the feed lever (59). Thus the slide is connected with the action lever bar (46). There is also in the feed block a stationary pawl (64) which projects up under the belt and prevents it slipping backward when the pawl is moved to the right to engage the next cartridge. To facilitate the entrance of the cartridges, the feed block is provided with a belt roller (65), and, in addition, has steel guides fixed above and below in the cartridge way, which insure the cartridges coming to the exact position where they can be seized by the carrier. They are prevented from being pushed too far through to the left by means of the cartridge and bullet stops, which are inside the feed block.

The action of the mechanism is as follows: When a cartridge is fired, the gases escaping from the muzzle enter the gas chamber (42) and force the yoke (44), piston (43), and action bar (48) forward about 1 inch, thereby moving the lower arm of the action lever (51) to the front. This brings the upper arm of the action lever into contact with lower arm of the crank handle (69), thereby rotating the handle to the front and the crank downward to the rear, which draws the lock rearward from the barrel and winds up the clock spring. The forward motion of the action bar compresses the action-bar spring (49) and moves the upper pawl in the feed block to the right so as to engage the next cartridge in the belt. When the lock moves backward the carrier (17) withdraws the empty shell from the barrel and a fresh cartridge from the belt. The carrier moves directly rearward until the cartridge is clear of the belt, when it falls partly by its own weight and partly by the action of the cover cam guides (93) until the cartridge is in line with the barrel and the empty shell in line with the ejector tube (26).

When the force of the gases is expended, the clock spring (74) unwinds itself in recovering its normal position, thereby revolving the crank so as to force the lock forward against the barrel. At the same time the action-bar spring (49) recovers itself and forces the action bar (48), yoke (44), and piston (43) back to their normal positions. As the action bar travels to the rear it moves the upper pawl on the feed-block slide to the left and thus brings up automatically a fresh cartridge into position in the feed block. As the lock moves forward into the firing position the live cartridge and the empty shell are respectively inserted in the chamber and ejector tube (26). The carrier (17) is moved upward by the horns of the crank acting on the lifting levers, thereby leaving the empty shell in the ejector tube until pushed out by the next shell, also causing the live cartridge to slide over the gib until opposite the firing-pin hole and engaging the next cartridge in the feed block. The carrier reaches its highest position before the crank has finished its travel, so that during the latter part of its movement the crank pin causes the lock to press the carrier hard against the end of the barrel, thus giving an additional forward motion to the lock and thereby tightening up all the joints in the breech mechanism and supporting it firmly against the barrel at the instant of firing.

The turning of the crank handle to the front not only draws the lock away from the barrel, but also gives a downward motion to the crank pin. The latter, bearing on the tail end of the tumbler (6), rotates it on its axis, and the head of the tumbler being engaged in a recess in the firing pin (4) forces the latter to the rear, compressing the lock spring (11). When the notch of the tumbler has moved above the point of the hand sear (8), the latter is forced by the hand-sear spring (10) under it and is thus able to hold the tumbler in the cocked position. The continued motion of the tumbler carries back the firing pin until the safety sear (2), which is acted upon by the lock spring (11), enters its notch in the firing pin. The firing pin is thus prevented from moving forward by both the safety sear and the hand sear, and consequently the gun can not be fired until released by both.

During the upward rotation of the crank the lock is moved to the front and when the latter is in its forward position the crank pin lifts the safety sear, thereby disengaging it from the firing pin, which then moves slightly forward till stopped by the notch of the tumbler engaging the point of the hand sear. If now the trigger push (83) is pressed forward, the trigger bar (82) is drawn backward, at the same time a projection on the latter engages and draws with it the tail end of the hand sear, thereby disengaging the tumbler and permitting the lock spring to propel the firing pin onto the cap. If automatic fire is desired the trigger push (83) is held forward so that when the lock moves forward the lower end of the hand sear comes in contact with the projection on the trigger bar, and its point is thus prevented from engaging the notch in the tumbler; the firing pin is therefore held only by the safety sear, and when the latter is lifted by the crank pin it is released and thrown forward onto the cap by the action of the lock spring. The release of the safety sear from the firing pin is so timed that it can not take place until the lock is in the firing position.

DESCRIPTION OF VICKERS SONS & MAXIM STANDARD PATTERN AUTOMATIC MACHINE GUN.

This gun is shown on Plate 9. Figure 1 is an elevation and Figure 2 a longitudinal cross-section of the gun. Figure 3, of Plate 10, is an elevation and Figure 4 a cross-section of the lock, recoil plates, crank, barrel, ejector tube, etc. Figure 5 is a cross-section and Figure 6 a plan of the feed block.

The gun submitted for test differs from that shown on Plate 9 in that the muzzle attachment is much larger in diameter, and a disk is attached to the front end of the barrel in order to increase the energy of recoil of the recoiling parts.

The recoiling parts of the gun consist principally of the barrel, recoil plates, crank, crank lever, and lock. These parts are moved rearward, the crank rotated and the counter-recoil spring extended by the energy of recoil imparted to the barrel by the powder pressure in the bore and also by the reaction of the powder gases after they leave the bore upon the disk attached to the front end of the barrel. These parts are moved forward and the crank rotated into their firing position by the counter-recoil spring.

The numbers of the parts correspond with those on the drawings.

NONRECOILING PARTS.

The water jacket (97) is of steel, holding 12 pints of water to keep the barrel cool when firing; it has three openings, one on the upper right side near the breech for filling (92), one underneath near the muzzle for drawing off the water (91), and the third (105), also near the muzzle, for allowing the steam to escape. The first two are closed with screwed plugs (91 and 92), the last is connected with the steam tube and is closed with a rubber plug (105). To prevent the escape of water there is at the forward end of the water jacket asbestos packing, which is held in position round the barrel by the rear portion of the muzzle attachment, which acts as a packing gland. At the rear end of the barrel there is a cannelure (38), also filled with asbestos packing, which prevents water leaking into the mechanism.

The rubber plug is provided to prevent waste of water when the gun is traveling.

Under the water jacket is the ejector tube (33), through which the empty cartridge shells are ejected from the gun. The tube is fitted with a spring (34) which prevents these shells falling backward into the gun when firing.

The steam tube is fitted in the water jacket above the barrel, and is secured in its proper position by means of a keeper screw (98) and lock screw (90) in the front face of the water jacket; it consists of two tubes, one fixed (89), having a hole near each end, the other (96) arranged to slide freely outside of it and termed the slide valve. If the gun is fired at an elevation, this valve slides backward, and, closing up the hole at rear end of tube, prevents water entering; at the same time it leaves the front hole uncovered, which, being above the water level, allows the steam to enter the fixed tube and to escape through a hole bored in the solid part of the front end of the water jacket, with which the tube is connected. Similarly, if the gun is fired at a depression the valve slides forward, uncovers the rear hole and allows the steam, but not the water, to escape.

The breech casing consists of two outside plates (55), a bottom plate (53), and the rear end (46), the whole being closed by a cover (40).

The outside plates are dovetailed into the water jacket, and together with the cover are secured by means of a cover joint pin (39). In both plates are slots (79) in which the crank bearings (78) move, partly closed by filling-in pieces (56); on the inside of both are solid cams which control the path of the carrier (19). On the outside of the right-hand plate there are the following fittings, viz: A roller (58) and check lever (59), both of which pivot on a stud on the right filling-in piece. The check lever (59) is kept in position by the roller (58), which, in turn is secured by a collar and split pin. On the outside of the left-hand plate are three studs for holding the counter-recoil box, the rear one being on the left filling-in piece.

The bottom plate is riveted to the two outside plates; the two rear rivets being left of extra length inside to form a guide for the trigger bar. Along the bottom lies the trigger bar (48), and underneath is a bracket (54) to which is attached the elevating gear by means of the elevating joint pin.

The outside plates are connected at the rear end by the rear cross-piece (46) into which they both dovetail, and in addition there is passed through the outside plates and rear cross-piece a split pin (82) which keeps the latter in position. This split pin has a T-shaped head to facilitate its removal. The rear cross-piece is fitted with two hollow handles for traversing, which are also used for carrying oil. In the center of the rear cross-piece a firing lever (47) is pivoted, the lower end of which is attached to the trigger bar, while the upper end is provided with a double button for firing and an automatic safety catch (50), which is so arranged that unless it is pressed down the firing lever can not be pushed forward.

The cover (40) is fitted with a gun-metal block (43) having cams which insure the extractor (19) dropping on recoil; this block keeps the lock down when back; at its rear end there is a spring catch (44) to fasten the cover to the rear cross-piece. On the upper surface is the tangent sight, which is graduated up to 3,000 yards.

The barrel (32) is coated with copper, to protect it from rust; the breech end is formed in the shape of a block which has a trunnion on each side, by which the barrel is attached to the recoil plates (31).

The muzzle of the barrel projects through the front end of the water jacket into a muzzle attachment. This attachment consists of a steel cylinder, the rear end of which is screwed into the water jacket head and forms the front bearing for the barrel. The front end of this attachment has a hole slightly larger in diameter than the bullet, through which the latter passes. Its rear surface is concave, so that the powder gases impinging on it are deflected against the disk on the barrel, thereby increasing the energy of recoil of the latter. Slots in the cylinder permit egress of the gases therefrom.

The recoil plates (31) are each provided with a hole to receive the barrel trunnions, and also grooves in which the flanges of the lock move. In addition, each has a bearing through which the crank (27) passes, thus connecting the latter with the barrel. These bearings move in slots in the breech casing. The right recoil plate is fitted with an extractor holding-up spring near the barrel. The left recoil plate is prolonged to the front, and has a recess in which the lever (70) on the under side of the feed block engages.

The crank (27) is fitted on the right with a handle (57), the lower surface of which bears on the roller (58) and is of a special curved form; on the left it is fitted with a fusee, to which are attached two links by which it is connected to the counter-recoil spring (63); the remainder of the crank is inside the breech casing, while in the center there is a connecting rod (25), which is free to turn on the crank-pin.

On the left of breech casing there is the counter-recoil spring (63), the rear end of which is connected with the crank; the front end is attached to the breech casing by means of the spring box (62) and adjusting screw (76).

The lock consists of the following parts, viz, casing (1), side levers (15), extractor (16), firing pin (5), safety sear (2), with spring (3), tumbler (6), extractor levers (11), trigger (8), and mainspring (10); also, axis pins for safety sear (4), side levers (15), tumbler (7), and trigger (9). The lock is attached to the connecting rod by a bayonet joint, and when in the firing position closes the breech, in which position it is held by the side levers, connecting rod, and crank. The lock has a reciprocating motion communicated to it by the rotation of the crank, and is kept in position during its backward and forward movements by means of flanges working in grooves in the recoil plates.

The extractor (16) is attached to the front end of the lock by guide ribs, upon which it has a vertical motion, and is fitted with extractor spring (24), gib (21), gib spring (22), and cover (23). The projections on the extractor spring and gib, together with the cartridge grooves, form recesses which retain the cartridge in position.

The extractor is moved upward by means of the side and extractor levers, and when in its highest position, is retained there by means of the extractor holding-up spring, which insures the hole for the firing pin being opposite the center of the primer when the lock is fully closed. The upward and downward movements of the extractor are regulated by the guide ribs and stops.

The gun is supplied with cartridges from a belt which passes through the feed block (65) from right to left. This belt is formed by two pieces of flax webbing connected together by eyelets and brass strips between adjacent cartridges; the projecting strips guide the belt through the feed block and prevent side motion of the belt in the ammunition box. The webbing is made thick at the edge next the bullets by being folded over a piece of cord, so that the cartridges may be kept parallel through the feed block and lie even in the ammunition belt boxes. The feed block is provided with a slide (69) to which are attached two pawls (68) with a spring for the purpose of moving the cartridges from right to left; the slide (69) has a transverse motion given to it by means of a lever (70) which has two arms; the top arm has a slot which engages a stud on the slide, and on the lower arm is a stud which engages in a recess in the left recoil plate. Thus the slide is connected with the recoiling parts. There are also in the feed block two stationary pawls (67) retained in position by a spring; these project up under the belt and prevent it slipping backward while the top pawls are moving to the right to engage the next cartridge in the belt. The feed block is provided with steel guides fitted above and below in the cartridge way; the upper guide is a spring having a rib which engages in the cannelure in the head of the cartridge, thereby insuring the cartridges coming to the exact position where they can be seized by the extractor; the cartridges are prevented from being pushed too far through to the left by means of the cartridge and bullet stops, which are inside the feed block.

The action of the mechanism is as follows: When the gun is fired the energy imparted to the recoiling parts by the powder gases causes them to move rearward. During this motion the crank handle is rotated to the front by the roller, which rotates the crank down and to the rear, thereby withdrawing the lock from the barrel and depressing the finger of the tumbler which retracts the firing pin until caught by the safety sear. During this motion of the lock the extractor first moves directly to the rear, carrying the empty shell and a cartridge from the belt, and when the latter is clear of the barrel the extractor is moved downward until the cartridge is opposite the chamber and the shell opposite the ejector tube.

During the rearward motion of the recoiling parts and the rotation of the crank the counter-recoil spring is extended. The energy thus stored in the spring moves the recoiling parts forward and rotates the crank upward, thereby returning all parts to their firing positions. This rotation of the crank moves the lock forward and inserts the cartridge in the chamber and the empty shell in the ejector tube. During the last part of this rotation the side levers cause the extractor levers to raise the extractor until caught by the holding-up spring. As the extractor rises it catches the cartridge in the belt, releases the empty shell, and the cartridge in the chamber slides over the gib and is held with its primer opposite the firing-pin hole.

During the downward rotation of the crank, the side levers bear on the tail end of the tumbler and rotate it on its axis and, as the point of the tumbler is engaged in a recess in the firing pin, force the latter to the rear, compressing the lock spring. When the notch of the tumbler has moved above the point of the trigger the latter is forced to engage with it by the action of the lock spring, and it thus holds the tumbler in the cocked position. The continued motion of the tumbler carries back the firing pin until the safety sear engages in its notch in the firing pin. The firing pin is thus prevented from moving forward by both the safety sear and the tumbler, so that the firing pin can not move forward unless both are disengaged.

During the last part of the upward motion of the crank, the rear end of the side levers lifts the safety sear, thereby disengaging it from the firing pin, which then moves slightly forward until stopped by the tumbler, the notch of which is engaged by the point of the trigger. If the upper end of the firing lever is now pressed forward, the trigger bar will be drawn rearward and the projection thereon will engage and draw with it the tail end of the trigger, thereby releasing the tumbler and allowing the lock spring to cause the firing pin to strike the primer.

If the firing lever be kept pressed forward, the trigger bar will hold the trigger disengaged from the tumbler so that when the upward motion of the side levers causes the safety sear to release the firing pin the latter will, under the action of the lock spring, strike the primer. This is the action of the parts during automatic fire. This gun is designed to fire automatically at the rate of 600 rounds per minute.

The sides and bottom of each ammunition box is made of ½-inch and the ends and lid of ⅝-inch oak. The lid has a brass hinge, spring catch, and counter-sunk handle. Each box holds one belt containing 250 cartridges.

The loading machine (Plate 11) consists of a frame carrying a crank, by which a backward and forward motion is communicated to the loop-opener and the cartridge inserted. The former is flat and pointed and is inserted and rotated in the loop so as to open it for the cartridge. As the opener is withdrawn the cartridge inserter catches the lowest cartridge in the feed guide and inserts it in the loop. The feed guide is arranged so that cartridges packed in clips may be stripped directly into it. A second feed guide is furnished, into which cartridges packed in paper boxes may be stripped. The belt passes around a roller on the underside of the frame, thence over the top of the latter, in which it is secured by a gate. During the insertion of each cartridge in the loop a dog is retracted, which moves the belt so that the next loop is opposite the loop opener. The operating handle may be turned in either direction. The machine can be clamped to a bench, empty cartridge box, etc.

The combined carriage and tripod (Plate 12) consists of a three-legged tripod and an axle and two wheels. The tripod can be attached to the axle. The tripod has three legs, made of steel tubing, attached to the pintle bracket; the rear leg is much longer and larger in diameter than the two front ones. The two front legs terminate at the top in a flat bronze casting, slotted to receive the screw by which each is clamped to the pintle bracket; at the lower end of each is a circular shoe provided with a steel point. The rear leg terminates at its lower end in a lunette containing a socket in which a wooden maneuver bar may be inserted, and the underside of which is flat and provided with a steel point. The upper end of this leg is assembled in the pintle bracket. The pintle bracket receives the pintle socket of the top carriage and at its rear end has a track of 58½ inches and tires 2½ inches in width.

The sleigh mount consists of two steel frames. The two side rails of the rear frame terminate at their front ends in circles and their rear ends in circular shoes provided with steel points. The upper end of the front frame can be turned around the axis of the circles on the rear frame, and each side rail has a spring clamp which engages in slots in the circular pieces, thereby enabling the front frame to be locked at any desired angle with or parallel to the rear frame. The latter provision is made to enable two men to carry the mount and gun. An elevating arc is attached to each side rail of the rear frame. The front end of the top carriage is pivoted on the axle of the circular pieces and its rear end can be locked to the two elevating arcs. Near the center of the top carriage is pivoted a pintle, to which the gun is trunnioned, and to which is attached a small shield. At the rear end of the top carriage is an elevating screw having a small motion in azimuth. The two elevating arcs pass through recesses in the top carriage and have notches in their rear faces. In rear of the elevating arc recesses in the top carriage are handles, each of which is provided with a spring catch which engages in the teeth on the elevating arcs and locking the rear end of the top carriage thereto. The elevation is given roughly by means of the elevating arcs, final adjustment being made by the elevating screw.

After the completion of the field tests the Vickers Sons & Maxim Company submitted a tripod mount (Plate 13), which consists of three legs, pintle bracket, and top carriage. The three legs are made of steel tubing, the two front being 1½ inches and the rear one 2 inches in diameter. The lower ends of the front legs terminate in shoes, from each of which a steel point projects; each of their upper ends terminate in a flattened piece slotted to receive a clamp screw and provided with a cylindrical tit at its upper end, which is inserted in a recess in the pintle bracket to prevent accidental rotation of the legs during firing. The rear end of the pintle bracket forms a traversing lug, on the top surface of which the rear end of the top carriage rests. This traversing lug contains a screw by which two clamps may be locked so as to either prevent any movement of the gun in azimuth or to limit such motion within any desired angle obtainable with the device. The front end of the pintle bracket has a clip which engages over a lug on the top carriage.

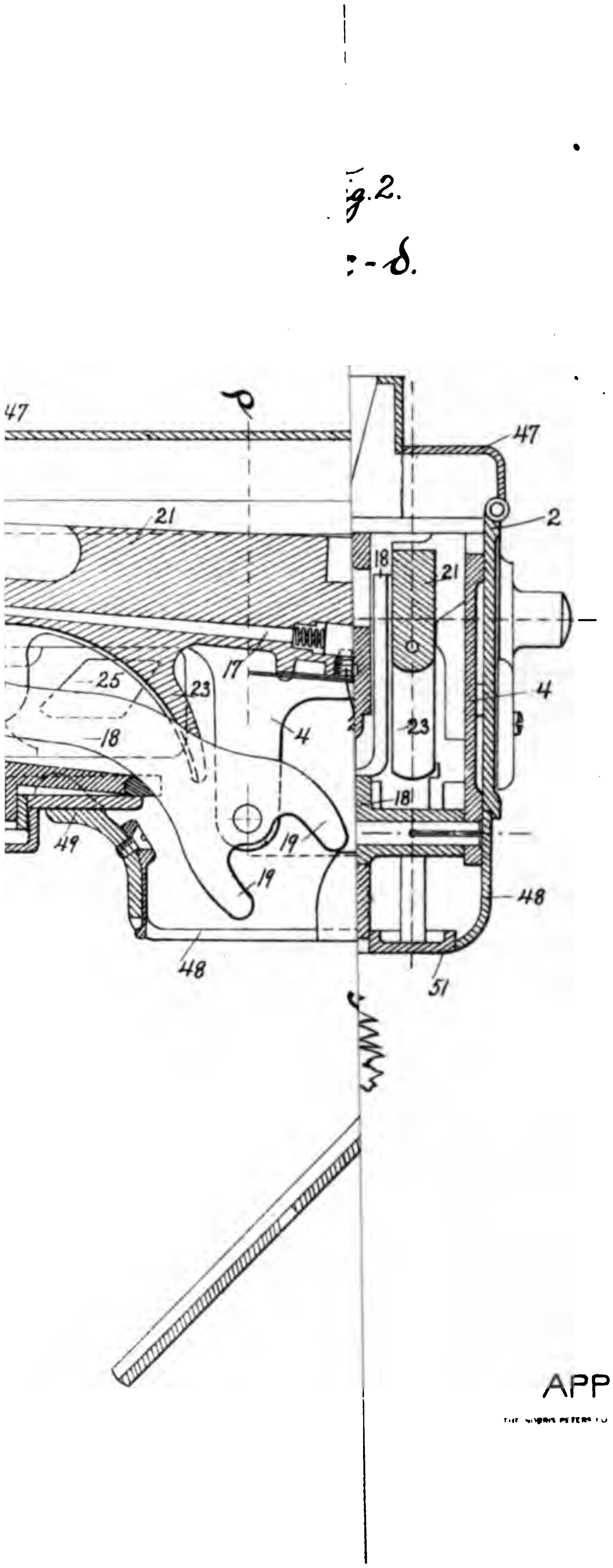
The top carriage is a single bronze casting having on top two trunnion arms to receive the gun, in its underside a pintle socket, and in front a clip lug. At its rear end is the traversing shoe and the slot in which the elevating-screw bracket is pivoted. The elevating mechanism consists of a double screw, the inner one being pivoted in the lug on the underside of the gun, the outer one having a handwheel attached to its top and working in the elevating bracket. The elevating bracket is a single casting pivoted in the top carriage, and its rear side is slotted and provided with a clamp screw. The axle is steel, the wheels have wooden spokes and felloes, and metal knave boxes. Each wheel is held on the axle by a linchpin and washer. The pintle bracket of the tripod is curved on its underside to fit the axle and is secured to it by two pins. On the rear leg of the tripod is a metallic seat for the gunner. The wheels are 43½ inches in diameter, have a track of 41½ inches, and tires 1¾ inches in width.

The galloping carriage consists of a metallic frame assembled on a steel axle, and is provided with a pole and also a pair of shafts. The middle portion of the frame contains a seat in which the sleigh mounting is carried. On each side of this seat is a steel ammunition chest which holds seven ammunition boxes, or 1,750 rounds. The lids of these chests are arranged so as to form shields. Attached to the frame is an axle-grease can, water tank, and two baskets for carrying empty belts, tools, etc. The wheels have wood felloes, spokes, and hubs, and each is secured to the axle by a linchpin and washer. The wheels are 55 inches in diameter, have recess which receives a lug on the front of the pintle bracket when the two front legs are turned forward into the same plane with the rear one, for carrying the tripod and gun by hand. On the rear end of the rear leg is a casting, the bottom surface of which is flat to form a shoe, in which are two points to prevent slipping on the ground. The rear end of a metal seat is attached to the top surface of this casting. About 3 inches in front of this casting, two handles are attached to the leg by means of a band. The pintle bracket is a hollow bronze casting, in which the rear leg is inserted and riveted, and to which the front legs are attached by clamp screws, the inner ends of which are fixed in the bracket and the outer ends of which are provided with thumbscrews. The upper surface of the bracket terminates in a pintle, on which the top carriage moves in azimuth and to which it is assembled. In the rear of the pintle is a traversing lug, which carries a clamp screw and two clamps, by means of which the gun can be locked in azimuth or its oscillation in azimuth limited within 1½ inches. A socket is attached to the rear leg, in rear of the pintle bracket, to receive a wooden handle-bar to enable six men to carry the gun and tripod. The top carriage is a single bronze casting, having a socket which receives the pintle and two arms in which the gun is trunnioned. On the underside of an arm projecting to the rear is a shoe which rests upon the traversing lug of the pintle bracket, and at the end of the arm is hinged the elevating mechanism. The elevating mechanism consists of a lower steel screw having a left-handed thread and of a top elevating screw of steel having a right-handed thread, which is attached to the lug on the underside of the gun casing.

The nut is a bronze casting having 4 handles by which it can be turned; its ends are threaded to receive the two elevating screws. As the upper screw is hollow, the two screws can be run fully into the nut, the lower entering the upper one. The top end of the nut is provided with a brass clamp screw. The cleaning rod can be inserted through a hole in the front of the pintle bracket into the rear leg, and held therein by a strap attached to the pintle.

38356–54–Encs. 1 and 2.

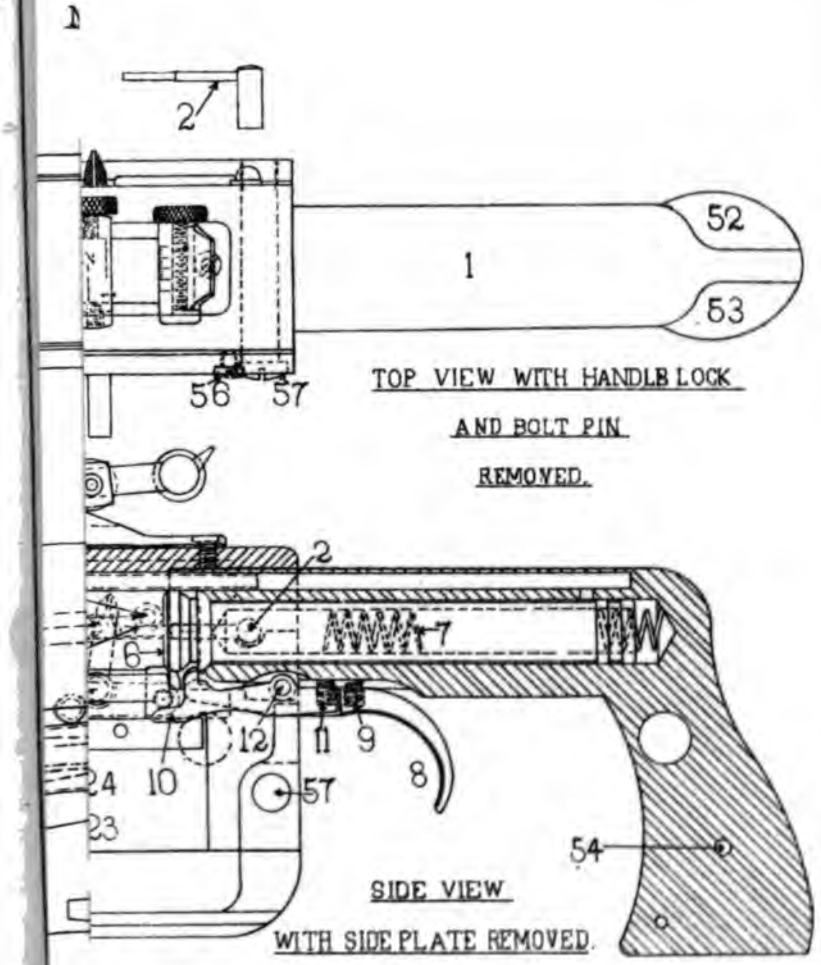
PLATE I.



APPENDIX I, 1904

THE NORRIS PETERS CO. PHOTO-LITHO., WASHINGTON, D.C.

PLATE 4.



TOP VIEW WITH HANDLE LOCK AND BOLT PIN REMOVED.

SIDE VIEW WITH SIDE PLATE REMOVED.

APPENDIX I, 1904.

APPENDIX II.

RESISTANCE OFFERED BY CUPRO-NICKEL BULLETS WHEN FORCED THROUGH BORE OF CALIBER .30 BARREL.

(8 plates.)

DESCRIPTION OF TESTS.

The tests were made with two .30-caliber rifle barrels of the service magazine rifle type, having a length of barrel of about 24 inches. The rifling of one barrel had a twist one turn in 10 inches; the other had a twist of one turn in 8 inches.

Steel-jacketed bullets of ¼-inch, ⅜-inch, and ½-inch length of bearing surface, respectively, were forced through the bores of these two barrels successively in the order reported below. No lubricant was used excepting that which was on the bullets when received for testing.

For the purpose of facilitating the tests a portion of the powder chamber of each barrel was cut off a short distance to the rear of the base of the bullet, which gave access to the bullet at the commencement of each round, whereby the forcing piston could be accurately centered. The annular space which would exist along the base end of the bullet when the test began was filled by means of a bushing made from a cartridge case, which cartridge had been fired in another rifle and expanded to the shape of the powder chamber. The lateral support thus given to the base end of the bullet was needed until the bullet had passed beyond the ordinary limits of the cartridge case and fully entered the bore. The employment of a cartridge case as a bushing had the further advantage of assimilating to the conditions of ordinary firing.

A device consisting of an antifriction screw and nut was tried as a buttress between the end of the forcing piston and the compression platform of the testing machine. The pitch of the thread of this device had an inclination very nearly to the angle of friction and in the opposite hand from the twist of the rifling. The function of this apparatus was to enable the piston to follow the rotation of the bullet, eliminating frictional resistance between the forward end of the piston and the base of the bullet, and by so doing to avoid excess of pressure on the forcing side of the lands. The principle of this device, which had worked satisfactorily in the case of projectiles of larger caliber which were pulled through the bore, was not in the present instance found serviceable, owing to an unsteadiness of rotary movement of the screw in its nut, and the device was abandoned. The contact surfaces of the piston and bullet were lubricated as the best practical means of reducing the frictional resistance in question.

At the commencement of each round and series of observations a slow speed was used for the velocity of travel of the bullet, and the resistance determined at frequent intervals until the bullet had passed beyond the stage of fully engaging the rifling. After this the velocity of travel was increased, attaining for a considerable time of the testing a velocity of .083 foot per minute.

Four pistons were used, of different lengths, beginning with the shortest and passing to the longer ones as the stroke of each was exhausted. The resistance of the bullets was such that an unsupported piston of adequate length to begin and complete a test with would not present sufficient strength against lateral deflection and would buckle under the pressure. When a new piston was employed a slower velocity was temporarily used.

All considerations duly weighed, it did not appear that the frictional resistance of the bullets was materially affected by the different velocities used in the present tests. There were fluctuations in resistance shown, which were thought to have their origin in other causes which pertain to the condition of the surfaces of the bullets after they had passed through a portion of the barrel. The bullets in general displayed abraded bearing surfaces at the close of the test, and it was noticeable that bullets which were the least abraded gave curves of lower resistance.

The condition of the bores of the barrels could not be accurately judged of, but to all appearances they remained in good condition. If they were materially scored by the passage of the bullets, the brightness of the bore obscured the detection of such effect.

The fourth test of each barrel was made with a bullet of ¼-inch bearing surface, duplicating the first test, for the purpose of comparing the resistance of the same type of bullet initially and at a subsequent period.

It will be observed, in contradiction to the behavior of earlier tests (see Report of Tests of Metals, 1896) on the resistance of copper-banded projectiles in the bores of guns of larger caliber that the maximum resistance of these bullets was not generally reached in the early stages of the test. The period during which the bullets were being fully engaged in the rifling was not characterized by greater resistance than was encountered at later periods in their passage along the bore. This behavior is thought to result from abrasion of the steel jacket increasing in degree during the travel of the bullet. Removal of the surface metal of the jacket after its initial displacement by the lands through abrasive influences would tend to relieve frictional resistance, but prior to such a condition the increasing roughness of the surface of the bullet would promote the display of increased resistance. The difference between the frictional resistance of the bullet from a state of rest and while in motion, observed at the time of changing pistons, showed in general diminished resistance when the bullet was again put into motion. This would appear to be accounted for, to some extent at least, by the flow of the lead in the bullet during the interval between pressures partially relieving the jacket of the lateral thrust of the lead for the time being.

Exceptional resistance was shown by the bullet in test No. 4, which was allowed to remain in the barrel after 19 inches of travel for an interval of seventeen hours, which increased resistance was attributed to the severely abraded surface of the bullet.

The forcing side of the lands disturbed the metal of the jacket to a greater extent than the opposite side. The abraded metal was more pronounced under the lands, but the general bearing surface of the bullets showed abrasion, both abreast the lands and the grooves, in varying degree in the different tests.

Tests were made at a speed of bullet of about 1 foot per minute, in which test the maximum resistance alone was determined, the only observation feasible to make at this speed of travel. The highest resistances of the tests were displayed at this time, but for reasons above mentioned these results were attributed more directly to the condition of the surfaces than to change in velocity.

No. 1.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifle barrel.*

[Rifling of barrel: Twist one turn in 10 inches. Bullet with bearing surface one-fourth inch long.]

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.	0.	1	28	00	
97	.05	.004	1	29	00	
106	.07	.003	1	29	30	
179	.10	.003	1	30	30	
269	.15	.008	1	31	00	
354	.20	.008	1	31	30	
378	.22					
486	.25	.001	1	38	00	
588	.30	.004	1	39	00	
790	.35	.004	1	40	00	
874	.40	.006	1	40	45	
966	.45	.017	1	41	00	
1,007	.50	.004	1	42	00	
1,048	.55	.004	1	43	00	
1,044	.60	.008	1	43	30	
1,038	.65					
990	.70	.017	1	44	00	
930	.75					
860	.80	.008	1	45	00	
775	.90					
720	1.00	.017	1	46	00	
700	1.10					
688	1.20	.017	1	47	00	
692	1.30					
720	1.40	.011	1	48	30	
720	1.50	.017	1	49	00	
702	1.60	.008	1	50	00	
676	1.80	.017	1	51	00	
700	2.00	.017	1	52	00	
662	2.20	.033	1	52	30	
658	2.50	.017	1	54	00	
624	2.80	.050	1	54	30	
636	3.00	.033	1	55	00	
635	3.50	.042	1	56	00	
615	4.00	.042	1	57	00	
625	5.00	.042	1	59	00	
						Changed pistons.
565	5.05		2	09	00	
684	6.00	.058	2	10	30	
682	7.00	.066	2	12	00	
692	8.00	.083	2	13	00	
686	9.00	.066	2	14	30	
678	10.00	.066	2	16	00	
712	11.00	.083	2	17	00	
						Changed pistons.
652	11.05		2	27	00	
636	12.00	.079	2	28	00	
600	13.00	.083	2	29	00	
602	14.00	.083	2	30	00	
573	15.00	.083	2	31	00	
596	16.00	.083	2	32	00	
616	17.00	.083	2	33	00	
580	18.00	.083	2	34	00	
571	19.00	.083	2	35	00	
						Changed pistons.
574	19.05		2	45	00	
595	20.00	.079	2	46	00	
602	21.00	.083	2	47	00	

No. 2.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifle barrel.*

[Rifling of barrel: Twist one turn in 10 inches. Bullet with bearing surface three-eighths inch long.]

Reisistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.	0.	10	51	00	
42	.05	....	....			
86	.10	....	....			
130	.15	....	....			
195	.20	....	....			
278	.25	....	....			
342	.30	.008	10	54	00	
422	.35	....	....			
504	.40	....	....			
586	.45	....	....			
665	.50	....	....			
760	.55	....	....			
830	.60	....	....			
862	.65	.007	10	58	00	
874	.70	....	....			
875	.75	....	....			
825	.80	....	....			
812	.90	.010	11	00	00	
782	1.00	....	....			
780	1.10	....	....			
776	1.20	.025	11	01	00	
755	1.30	....	....			
792	1.50	.013	11	03	00	
808	1.80	.017	11	04	30	
922	2.00	.011	11	06	00	
956	2.20	.033	11	06	30	
1,008	2.50	.025	11	07	30	
916	2.80	....	....			
898	3.00	.042	11	08	30	
783	3.50	.028	11	10	00	
750	4.00	.042	11	11	00	
770	5.00	.042	11	13	00	
						Changed pistons.
737	5.06	....	11	21	00	
916	6.00	.040	11	23	00	
978	7.00	.056	11	24	30	
998	8.00	.083	11	25	30	
970	9.00	.067	11	26	45	
948	10.00	.067	11	28	00	
952	11.00	.083	11	29	00	
						Changed pistons.
953	11.03	....	11	36	00	
912	12.00	.081	11	37	00	
830	13.00	.111	11	37	45	
861	14.00	.111	11	38	30	
832	15.00	.083	11	39	30	
850	16.00	.111	11	40	15	
852	17.00	.111	11	41	00	
846	18.00	.167	11	41	30	
838	19.00	.083	11	42	30	
						Changed pistons.
944	19.01	....	11	51	00	
905	19.06	.002	11	52	30	
899	20.00	.045	11	54	15	
990	21.00	.048	11	56	00	
900	21.20	....	....			
820	21.30	....	....			
640	21.40	....	....			
490	21.50	....	....			
200	21.70	....	....			

No. 3.—*Resistance of a steel-jacketed bullet when forced through the bore of a .30-caliber rifle barrel.*

[Rifling of barrel: Twist one turn in 10 inches. Bullet with bearing surface one-half inch long.]

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.	0.	1	06	00	
63	.05	....	....			
97	.10	....	....			
134	.15	....	....			
184	.20	....	....			
232	.25	....	....			
275	.30	....	....			
328	.35	....	....			
384	.40	....	....			
430	.45	.006	1	12	00	
498	.50	....	....			
568	.55	....	....			
658	.60	....	....			
755	.65	....	....			
788	.70	....	....			
806	.75	....	....			
800	.80	.008	1	15	30	
720	.90	.011	1	16	15	
698	1.00	.017	1	16	45	
710	1.10	....	....			
734	1.20	.010	1	18	30	
738	1.30	.017	1	19	00	
780	1.50	.022	1	19	45	
826	1.80	.025	1	20	45	
880	2.00	.033	1	21	15	
876	2.20	.033	1	21	45	
984	2.50	.033	1	22	30	
876	3.00	.042	1	23	30	
816	3.50	.042	1	24	30	
706	4.00	.056	1	25	15	
730	5.00	.048	1	27	00	
						Changed pistons.
690	5.02	....	1	33	00	
704	5.05	.003	1	34	00	
852	6.00	.026	1	37	00	
1,024	7.00	.056	1	38	30	
1,060	7.80	....	....			
990	8.00	.056	1	40	00	
998	9.00	.067	1	41	15	
1,000	10.00	.067	1	42	30	
1,096	11.00	.083	1	43	30	
						Changed pistons.
982	11.05	....	1	56	00	
1,060	11.70	....	....			
1,020	12.00	.040	1	58	00	
940	13.00	.083	1	59	00	
845	14.00	.083	2	00	00	
825	15.00	.083	2	01	00	
848	16.00	.083	2	02	00	
884	17.00	.083	2	03	00	
910	18.00	.083	2	04	00	
946	19.00	.083	2	05	00	
						Changed pistons.
980	19.02	....	2	16	00	
915	19.05	.005	2	16	30	
1,040	20.00	.158	2	17	00	
1,020	21.00	.083	2	18	00	
700	21.40	....	....			

No. 4.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifle barrel.*

[Rifling of barrel: Twist one turn in 10 inches. Bullet with bearing surface one-fourth inch long.]

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.		3	12	00	
35	.05					
64	.10					
102	.15					
167	.20					
230	.25	.007	3	15	00	
295	.30					
372	.35					
460	.40					
545	.45	.008	3	17	00	
616	.50					
710	.55	.008	3	18	00	
768	.60					
778	.65	.007	3	19	15	
796	.70					
800	.75					
770	.80					
715	.85					
712	.90	.012	3	21	00	
730	1.00					
730	1.10	.022	3	21	45	
756	1.20	.017	3	22	15	
793	1.30	.033	3	22	30	
738	1.50	.022	3	23	15	
925	1.80	.025	3	24	15	
958	2.00	.022	3	25	00	
976	2.20	.033	3	25	30	
953	2.50	.033	3	26	15	
840	2.80					
940	3.00	.033	3	27	30	
918	3.50	.042	3	28	30	
896	4.00	.042	3	29	30	
940	5.00	.083	3	30	30	
						Changed pistons.
853	5.01		3	38	00	
914	5.05	.002	3	39	45	
1,030	6.00	.045	3	41	30	
1,036	7.00	.056	3	43	00	
1,096	8.00	.083	3	44	00	
1,124	9.00	.083	3	45	00	
1,160	10.00	.083	3	46	00	
1,145	11.00	.083	3	47	00	
						Changed pistons.
1,050	11.05		3	55	00	
1,180	11.80					
1,140	12.00	.063	3	56	15	
1,220	12.60					
1,130	13.00	.048	3	58	00	
1,121	14.00	.083	3	59	00	
1,197	15.00	.167	3	59	30	
1,155	16.00	.111	4	00	15	
1,182	17.00	.083	4	01	15	
1,284	18.00	.111	4	02	00	
1,300	19.00	.083	4	03	00	
Bullet remained in barrel 17 hours, after which the test was completed.						
1,280	19.01					
1,046	19.02					
1,058	19.03					
1,070	19.04					
1,080	19.05					
1,150	19.10					
1,390	19.50					
1,640	20.00					
1,640	20.30					
1,610	20.50					
1,670	20.80					
1,450	21.00					
1,000	21.40					
700	21.50					
400	21.65					
0	[a] 21.85					

[a] About.

Tests on the maximum resistance of bullets forced through the barrel at a speed of about 1 foot per minute.

[Rifling of barrel: Twist one turn in 10 inches.]

No. of test.	Bearing of bullet.	Maximum resistance.	Remarks.
	Inch.	*Pounds.*	
10652	¼	1,800	1,450 pounds resistance until bullet had traveled nearly through.
10653	⅜	2,200	
10654	⅛	1,700	
			The barrel is perceptibly warmed during the passage of the bullets at 1 foot per minute velocity.

No. 5.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifle barrel.*

[Rifling of barrel: Twist one turn in 8 inches. Bullet with bearing one-fourth inch long.]

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.	0.	12	56	00	
56	.05	....	.....	.....	.....	
101	.10	....	.....	.....	.....	
176	.15	....	.....	.....	.....	
244	.20	.008	12	58	00	
363	.25	....	.....	.....	.....	
462	.30	....	.....	.....	.....	
588	.35	....	.....	.....	.....	
688	.40	....	.....	.....	.....	
783	.45	.010	1	00	00	
866	.50	....	.....	.....	.....	
892	.55	....	.....	.....	.....	
934	.60	.010	1	01	15	
956	.65	....	.....	.....	.....	
955	.70	....	.....	.....	.....	
936	.75	.010	1	02	30	
890	.80	....	.....	.....	.....	
838	.90	.013	1	03	30	
780	1.00	.011	1	04	15	
754	1.10	.017	1	04	45	
762	1.20	.011	1	05	30	
783	1.30	.017	1	06	00	
828	1.50	.022	1	06	45	
805	1.80	.020	1	08	00	
804	2.00	.022	1	08	45	
818	2.20	.033	1	09	15	
825	2.50	.025	1	10	15	
808	3.00	.033	1	11	30	
825	3.50	.056	1	12	15	
792	4.00	.056	1	13	00	
793	5.00	.083	1	14	00	
						Changed pistons.
640	5.02	....	1	23	00	
690	5.05	.003	1	24	00	
745	6.00	.040	1	26	00	
780	7.00	.083	1	27	00	
767	8.00	.083	1	28	00	
804	9.00	.083	1	29	00	
777	10.00	.083	1	30	00	
787	11.00	.083	1	31	00	
						Changed pistons.
640	11.01	....	1	39	00	
640	11.02	....	.....	.....	.....	
640	11.03	....	.....	.....	.....	
650	11.04	....	.....	.....	.....	
655	11.05	....	.....	.....	.....	
665	11.08	....	.....	.....	.....	
665	11.10	.003	1	41	30	
710	11.50	.033	1	42	30	
657	12.00	.083	1	43	00	
658	13.00	.083	1	44	00	
635	14.00	.083	1	45	00	
650	15.00	.083	1	46	00	
666	16.00	.083	1	47	00	
648	17.00	.083	1	48	00	
657	18.00	.083	1	49	00	
648	19.00	.083	1	50	00	
						Changed pistons.

No. 5.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifl barrel*—Continued.

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
485	19.01		2	08	30	
582	19.02					
576	19.03					
578	19.04					
578	19.05	0.001	2	11	15	
586	19.10	.017	2	11	30	
592	19.20	.008	2	12	30	
628	20.00	.033	2	14	30	
625	21.00	.056	2	16	00	
350	21.50					

No. 6.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifl barrel.*

[Rifling of barrel: Twist one turn in 8 inches. Bullet with bearing surface three-eighths inch long.

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.	0.	2	40	00	
54	.05					
92	.10					
152	.15					
232	.20	.004	2	43	45	
302	.25					
370	.30					
447	.35					
525	.40	.008	2	45	45	
623	.45	.006	2	46	30	
700	.50	.008	2	47	00	
812	.55	.008	2	47	30	
894	.60	.008	2	48	00	
925	.65					
942	.70	.008	2	49	00	
956	.75					
922	.80	.011	2	49	45	
861	.90	.011	2	50	30	
838	1.00	.011	2	51	15	
812	1.10	.017	2	51	45	
806	1.20	.017	2	52	15	
814	1.30					
828	1.50	.025	2	53	15	
874	1.80	.033	2	54	00	
920	2.00	.033	2	54	30	
942	2.20	.033	2	55	00	
947	2.50	.050	2	56	30	
954	3.00	.056	2	56	15	
984	3.50	.056	2	57	00	
1,000	4.00	.083	2	57	30	
1,068	5.00	.067	2	58	45	
						Changed pistons.
920	5.01		3	03	30	
956	5.05					
1,049	6.00	.066	3	04	45	
1,096	7.00	.067	3	06	00	
1,113	8.00	.067	3	07	15	
1,152	9.00	.083	3	08	15	
1,126	10.00	.083	3	09	15	
1,146	11.00	.083	3	10	15	
						Changed pistons.
1,135	11.01		3	18	30	
1,100	11.05	.002	3	20	00	
1,295	11.50	.038	3	21	00	
1,300	12.00	.056	3	21	45	
1,126	13.00	.056	3	23	15	
1,083	14.00	.067	3	24	30	
1,100	15.00	.083	3	25	30	
1,105	16.00	.067	3	26	45	
1,218	17.00	.083	3	27	45	
1,285	18.00	.083	3	28	45	
1,248	19.00	.083	3	29	45	
						Changed pistons.
900	19.01		3	36	30	
1,200	19.03					
1,132	19.05					
1,146	20.00	.028	3	39	30	
1,125	21.00	.083	3	40	30	
640	21.50					

No. 7.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifle barrel.*

[Rifling of barrel: Twist one turn in 8 inches. Bullet with bearing surface one-half inch long.]

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.	0.	9	14	00	
38	.05					
60	.10					
102	.15					
152	.20					
196	.25					
256	.30					
314	.35					
376	.40					
446	.45					
520	.50	.006	9	21	30	
592	.55					
662	.60					
710	.65	.006	9	23	45	
748	.70					
753	.75	.011	9	24	30	
767	.80	.008	9	25	00	
766	.90	.011	9	25	45	
762	1.00	.017	9	26	15	
724	1.10	.033	9	26	30	
702	1.20	.017	9	27	00	
706	1.30	.017	9	27	30	
761	1.50	.022	9	28	15	
802	1.80	.025	9	29	15	
834	2.00	.067	9	29	30	
859	2.20	.022	9	30	15	
884	2.50	.050	9	30	45	
930	3.00	.042	9	31	45	
926	3.50	.056	9	32	30	
966	4.00	.056	9	33	15	
1,013	5.00	.083	9	34	15	
						Changed pistons.
800	5.01		9	41	45	
895	5.02					
896	5.05					
898	5.04					
898	5.06					
740	5.10	.003	9	44	30	
1,052	6.00	.075	9	45	30	
1,105	7.00	.067	9	46	45	
1,156	8.00	.083	9	47	45	
1,182	9.00	.083	9	48	45	
1,115	10.00	.083	9	49	45	
1,077	11.00					
						Changed pistons.
985	11.01		9	56	15	
975	11.03					
984	11.05	.002	9	58	15	
1,022	11.10	.003	9	59	30	
1,080	12.00	.030	10	02	00	
1,112	13.00	.067	10	03	15	
1,156	14.00	.088	10	04	15	
1,198	15.00	.083	10	05	15	
1,142	16.00	.083	10	06	15	
1,140	17.00	.083	10	07	15	
1,042	18.00	.083	10	08	15	
1,052	19.00	.088	10	09	15	
						Changed pistons.
700	19.01		10	14	15	
970	19.03					
968	19.05	.001	10	16	80	
982	19.10	.008	10	17	00	
998	20.00	.060	10	18	15	
1,050	21.00	.167	10	18	45	

No. 8.—*Resistance of steel-jacketed bullet when forced through the bore of a .30-caliber rifle barrel.*

[Rifling of barrel: Twist one turn in 8 inches. Bullet with bearing surface one-fourth inch long.]

Resistance.	Distance bullet traveled.	Velocity per minute.	Time of observations.			Remarks.
Pounds.	*Inches.*	*Foot.*	*h.*	*m.*	*s.*	
0	0.	0.	11	09	30	
52	.05	....	....			
86	.10	....	....			
144	.15	....	....			
212	.20	....	....			
282	.25	....	....			
387	.30	....	....			
502	.35	....	....			
590	.40	.005	11	16	15	
670	.45	....	....			
781	.50	....	....			
880	.55	.007	11	18	00	
910	.60	....	....			
925	.65	....	....			
938	.70	....	....			
908	.75	....	....			
869	.80	....	....			
855	.90	....	....			
830	1.00	....	....			
800	1.20	.014	11	22	00	
795	1.30	....	....			
740	1.50	.017	11	23	30	
724	1.80	.020	11	24	45	
708	2.00	.022	11	25	30	
718	2.20	.017	11	26	30	
732	2.50	.020	11	27	45	
746	3.00	.056	11	28	30	
770	3.50	.021	11	30	30	
800	4.00	.042	11	31	30	
810	5.00	.056	11	33	00	
						Changed pistons.
720	5.01	....	11	40	30	
723	5.03	....	....			
725	5.05	.002	11	42	30	
788	6.00	.023	11	46	00	
815	7.00	.067	11	47	15	
850	8.00	.083	11	48	15	
900	9.00	.083	11	49	15	
918	10.00	.083	11	50	15	
939	11.00	.083	11	51	15	
						Changed pistons.
760	11.01	....	11	56	30	
786	11.03	....	....			
784	11.05	....	....			
860	12.00	.028	11	59	30	
814	13.00	.083	12	00	30	
786	14.00	.083	12	01	30	
795	15.00	.083	12	02	30	
818	16.00	.083	12	03	30	
866	17.00	.083	12	04	30	
882	18.00	.083	12	05	30	
822	19.00	.083	12	06	30	
						Changed pistons. Rested 1 hour and 6 minutes.
430	19.01	....	1	12	30	
800	19.03	....	....			
740	19.05	....	....			
732	20.00	.021	1	16	30	
740	21.00	.083	1	17	30	

*Tests on the maximum resistance of bullets forced through the barrel at a speed of about 1 foot per minute.**

[Rifling of barrel: Twist one turn in 8 inches.]

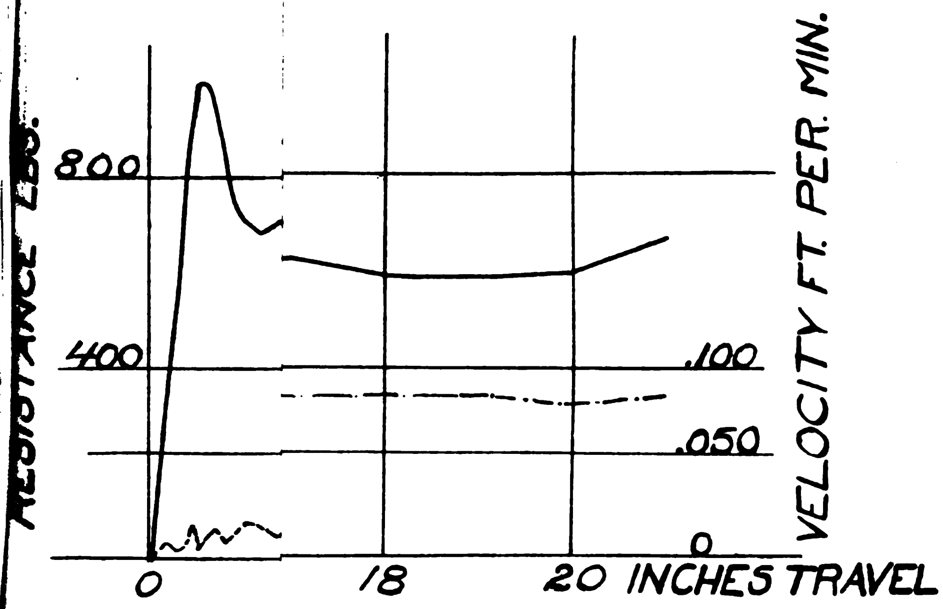
No. of test.	Bearing of bullet.	Maximum resistance.	Remarks.
	Inch.	*Pounds.*	
10659	$\frac{1}{4}$	890	
10660	$\frac{3}{8}$	1,450	
10661	$\frac{1}{2}$	1,800	
10662	$\frac{1}{4}$	1,220	
10663	$\frac{3}{8}$	1,680	
10664	$\frac{1}{2}$	1,640	
Additional tests with barrel having a twist of one turn in 10 inches.			
10665	$\frac{1}{4}$	1,000	
10666	$\frac{3}{8}$	1,550	
10667	$\frac{1}{2}$	2,020	
10668	$\frac{1}{4}$	1,300	

Correct.
J. E. HOWARD.

JOHN G. BUTLER,
Lieutenant-Colonel Ordnance Department,
U. S. Army, Commanding.

(26791-O—260-3.)

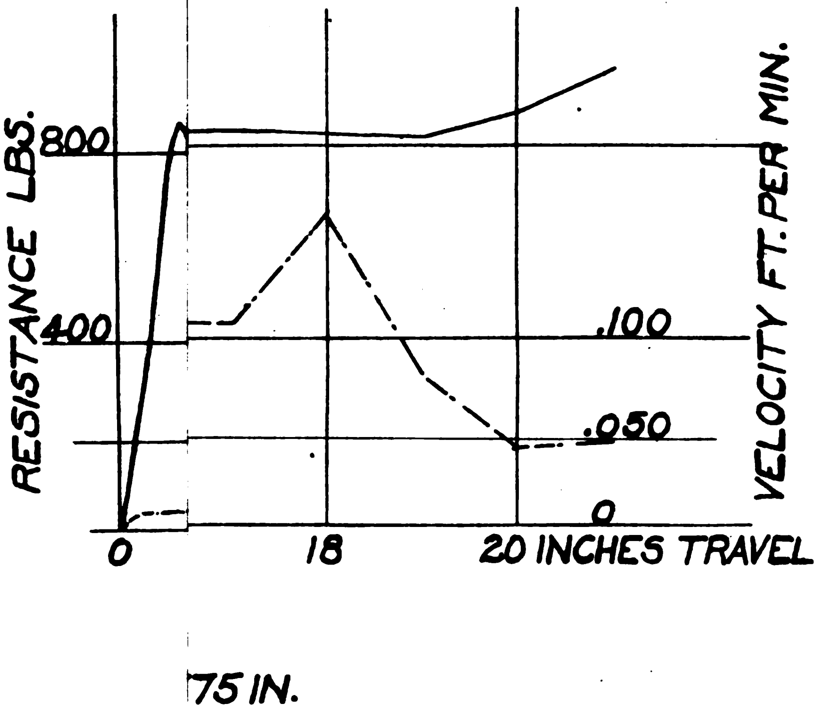
PLATE I



25 IN.

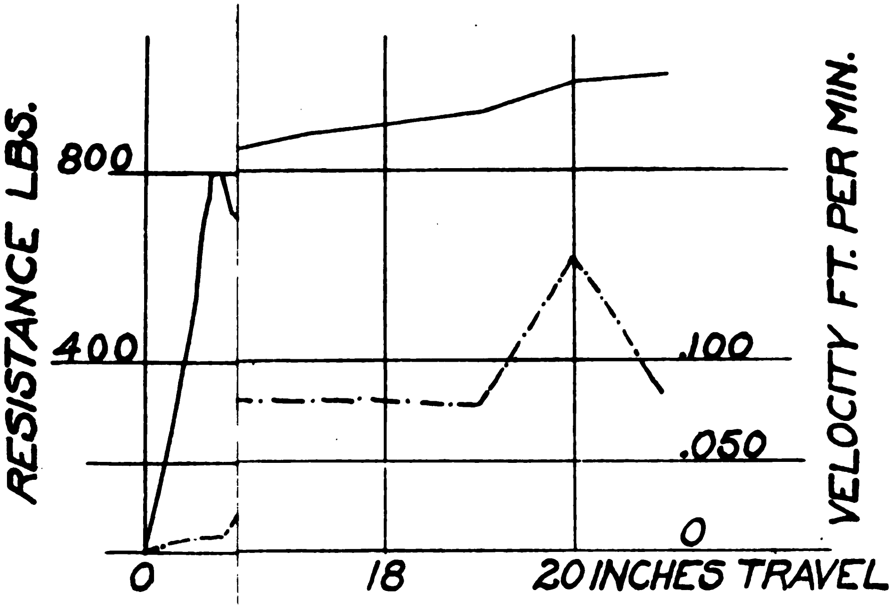
PPENDIX II-1904

PLATE 2



APPENDIX II - 1904

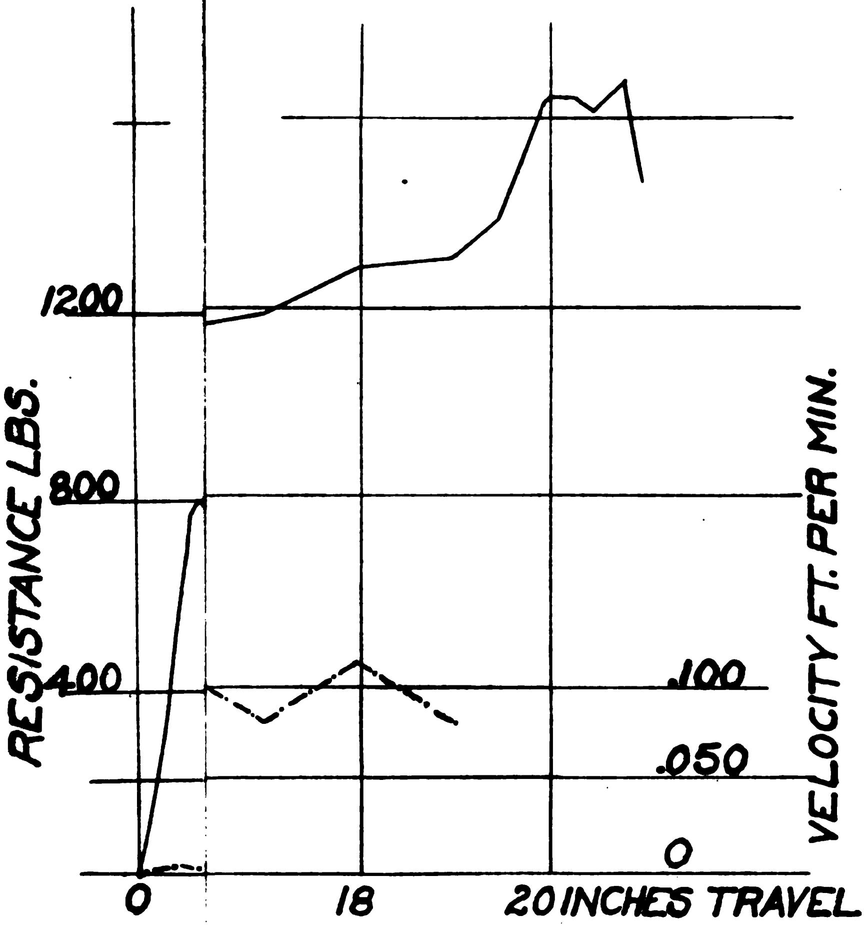
PLATE 3



THE NORRIS PETERS CO., PHOTO-LITH

APPENDIX II 1904

PLATE 4



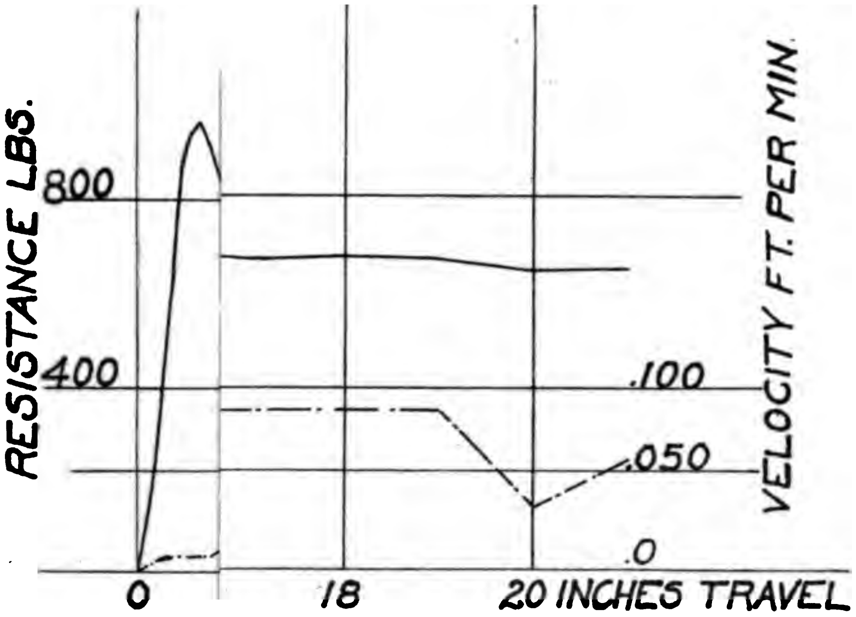
N.

NOTE. TRAVEL

THE NORRIS PETERS CO., PHOTO

APPENDIX II - 1904

PLATE 5



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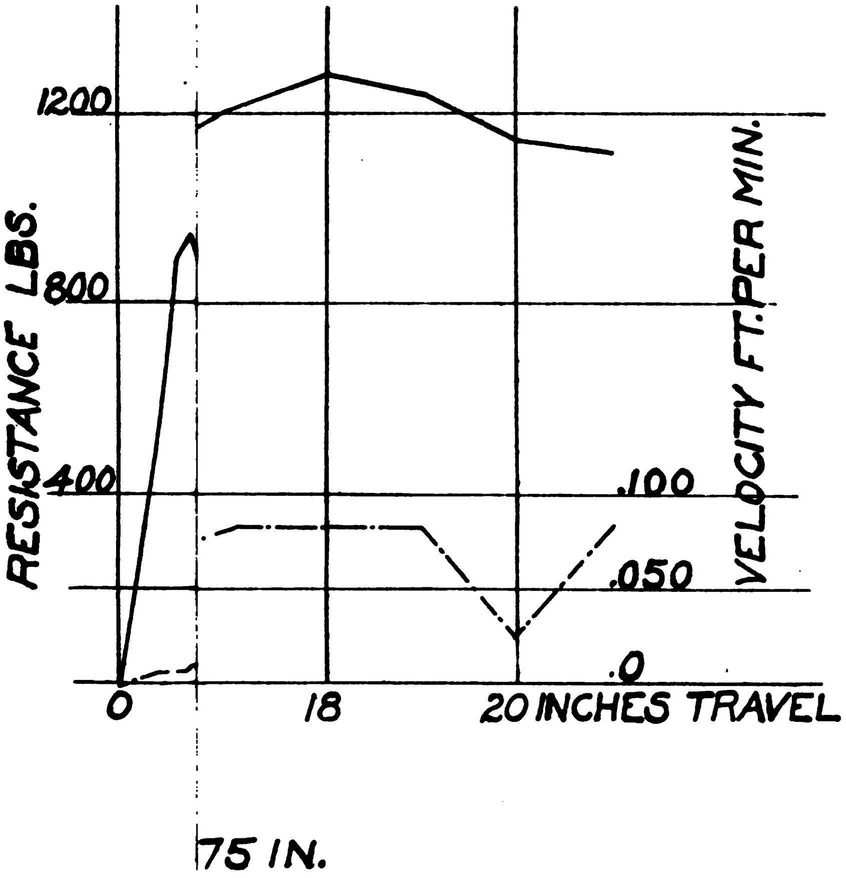
THE NORRIS PETERS CO. PHOTO-LITHO

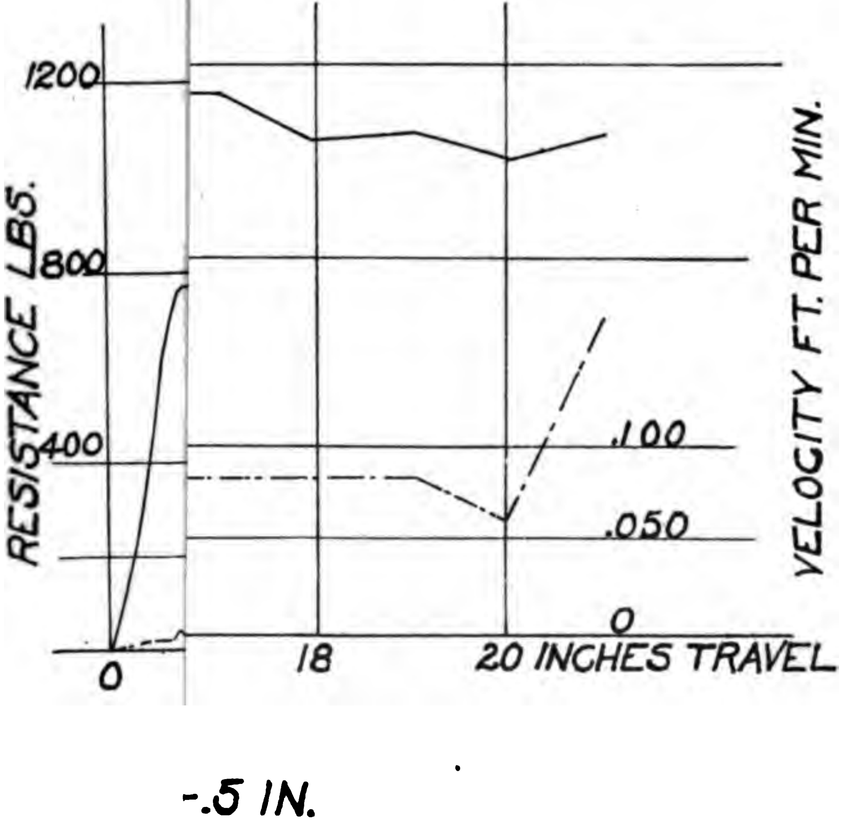
APPENDIX II - 1904

PLATE 6



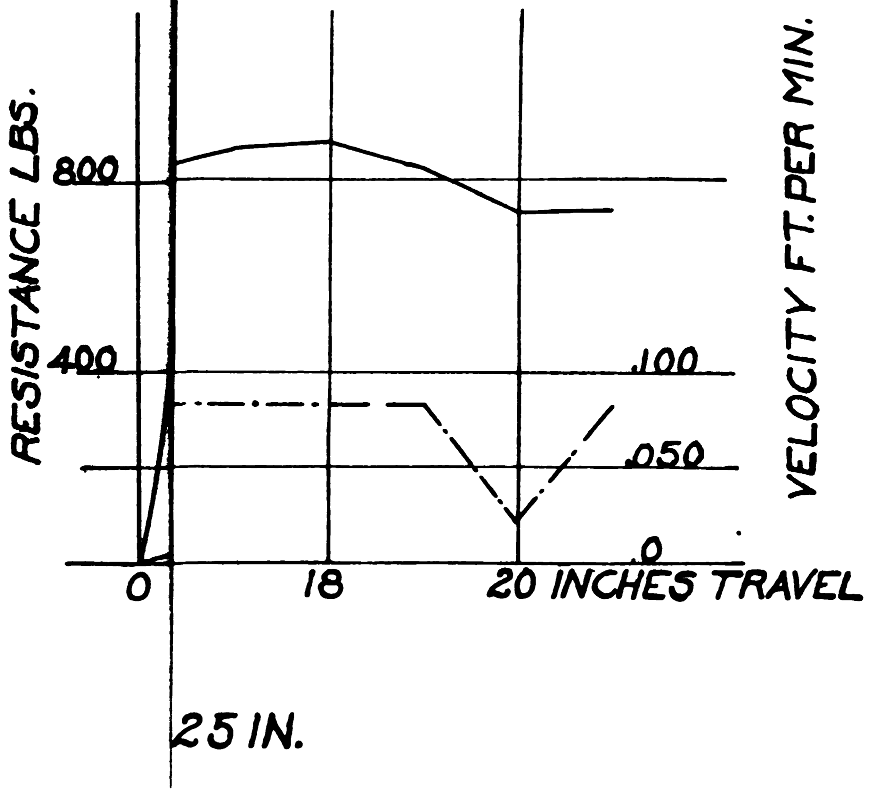
APPENDIX II - 1904

PLATE 7



APPENDIX II - 1904

PLATE 8



APPENDIX II - 1904

APPENDIX III.

TEST OF DIFFERENT WIDTHS OF TIRES WITH SIEGE ARTILLERY CARRIAGES.

(23 plates.)

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, January 25, 1902.

SIR: 1. In view of the recent recommendation of the board of artillery officers convened for the purpose of considering and reporting upon the equipment of batteries of siege artillery (O. O. 34473—inclosure 1, copy of which was sent you January 13, 1902), that the wheels of siege carriages and limbers should have tires 5 inches wide, and with a view to determining the relative merits of tires of the present width and those recommended, you are instructed to equip a 7-inch siege howitzer carriage and limber, with wheels having tires 5 inches wide, and to make road tests with the carriage thus equipped and one equipped with the present service wheels, using the tractograph for recording the tractive force required under various conditions of soil.

2. It is desired that all details of the test be included in a report, together with the increased weight of the wheels recommended over those now in service. This test should be undertaken and completed as early as practicable.

3. The office of public road inquiries, Department of Agriculture, have made tests with a view to the determination of the proper value of wide tires, and it is suggested that by corresponding with that office you may be able to obtain valuable preliminary information concerning the tests which you are about to undertake.

* * * * * * *

Respectfully,

WILLIAM CROZIER,
Brig. Gen., Chief of Ordnance.

The COMMANDING OFFICER,
Rock Island Arsenal.

In compliance with the foregoing instructions, a board composed of Maj. D. M. Taylor, Capt. T. C. Dickson, and Capt. L. M. Fuller was convened and the following programme was outlined, viz:

That 5-inch tires and tires of service width be tested on (1) macadam, (2) clay or hard country, (3) sand or dirt, (4) shallow mud, and (5) deep mud roads. The deep mud test was to be such that two horses could not move the equipment and that four could only do so with an effort. Inasmuch as the better classes of roads are seldom met with in actual campaign, and as it matters but little what kind of tires are used on these roads, it was proposed that the result obtained from each class of road be given a relative value by which it should be multiplied, the totals thus obtained for each width of tire over various roads to determine the desirable width for adoption. It was suggested that roads of the (1) class be given a multiplier of 1; of the (2) class, 2; of the (3) class, 3; of the (4) class, 4, and of the (5) class, 10. It is possible that the deep mud roads should have been given a higher rating, for while but a small proportion of the roads may be deep mud, the real question of military importance was, which class of roads would cause the greatest delay to military operations.

It was also proposed that supplementary tests be made, upon the conclusion of those above described, to determine if it be possible to reduce the tractive effort in deep mud by the addition of side plates to the wheels, or by other means that would secure the same results. These tests were not to be undertaken in connection with the competitive tests, but merely for the information to be derived therefrom.

Due to the relief of Captain Dickson from duty at the Rock Island Arsenal, Lieut. E. D. Bricker was detailed for duty on the board in his stead, and the following reports were submitted, viz:

The 5-inch wheels were received about the middle of July and the tests were begun as soon as they were fitted to the carriage and limber.

The tractographs used in these first tests are constructed as follows:

A worm is fitted to the hub of the limber and engages in a worm wheel at the end of a shaft, at the other end of which is a bevel gear. This bevel gear engages in another bevel gear on a shaft at right angles to the first and by means of a second set of bevel gears transmits the motion of revolution of the limber wheel to one of two cylinders on which is wound the paper that takes the record. The second cylinder is connected with the first by a belt, which serves to keep the paper stretched. Between the two cylinders is a table which is always under that part of the paper on which the record is being made and furnishes a smooth surface for the pencil points to move upon.

The doubletree is attached to a block with a collar passing around the pole. This block bears against two spiral springs, the other ends of which bear against a plate rigidly fastened to the pole. Attached to this block is a small arm which holds a pencil directly over the paper on which the record is to be made. This pencil is constantly pressed against the paper by means of a small spiral spring, but so arranged that it can be raised slightly and held above the paper by means of a screw when no record is being made. A second pencil, similarly arranged, except that it is not connected with the doubletree, serves to mark the line of origins on the record. This pencil is adjusted before starting, so that its point is on a line with the point of the first pencil.

The tractograph is so geared that in one turn of the limber wheel the paper will move 0.276 of an inch, or 1 inch on the record corresponds to 58.5 feet of travel of the limber.

The record is made as follows: The pull of the horses is transmitted directly to the doubletree and from thence to the arm carrying the pencil. The distance from the origin line to the point of the pencil at any time is the distance through which the spiral springs have been mpressed at that same time. The paper which is moving under the int of the pencil at the same time makes the record in the form of curve the ordinate of which at any point measures the correspondg compression of the springs.

A photograph of the first tractograph used (Pl. 1) gives a clear idea its method of attachment to the limber.

The first tests were made on August 7, 1902, two carriages and nbers being used, one equipped with service wheels, the other with e wheels with 5-inch tires. Each limber had its own tractograph, d each carriage and limber was drawn by two teams of horses, cept during the mud tests, where three teams were used.

Page 151 is the record of these tests.

In the deep-mud tests the springs were not strong enough to record e pull, the pencil ran off the paper, and the carriages in both cases uck in a mudhole. The pencil was lifted and the carriage pulled it, but for fear of wrecking the instrument the record was not ntinued.

After these tests, the tractograph on one of the limbers was strengthed by fitting to it two additional springs—four in all—and the subquent tests were all made with the same carriage and limber, the me tractograph, the same teams of horses, which necessitated merely anging the wheels for each series of tests. This, it was thought, ould make the tests as nearly comparative as possible, for the following asons:

The carriage and limber being the same, the weights were in all ses the same except for the difference in weight of the wheels.

The springs and mechanism of the tractograph being the same, any use affecting one record would similarly affect the others.

The same teams of horses being used in each case, the nature of the active effort would be as nearly the same as possible.

The next tests were made on August 11, with the instrument scribed above, and the record is entered under that date.

Three teams of horses were used, and the tests made over the folwing kinds of roads:

Macadam road--very hard and oiled to lay dust.

Fair country road—a dirt road with light mud in places.

Hard sand road—hard sand and gravel with a small hill.

Deep soft mud—In this road the wheels sank in places nearly to the ubs and large quantities of mud adhered to them.

The road brakes were put on twice on the macadam road and nce on the hard sand, to find what pull is required to draw the cariage and limber with the two carriage wheels skidded. It was thought his information would be of general value in carriage construction.

It will be seen from the tabulated record of these tests that the ervice tire, except in the case of hard sand road, shows in all cases a uperiority over the wide tires. The tests were made in the order iven, the wide tires being taken first. The service wheels were fitted the carriage and limber and greased with axle grease in the shop. hey were then drawn to the point of starting on the macadam road, distance of one-fourth mile. This distance was thought sufficient to pread the axle grease and cause the wheels to turn as easily as posible. However, when the first round of tests was completed the cariage was taken to the 'starting point on the macadam road and the wheels changed and again greased with axle grease. As the test on the macadam road began at this point, the axle grease, which is stiff at first, would, it is thought, account for the difference in effort required on this road. This test on the macadam road was not considered satisfactory, for the reasons given above, and a subsequent one was made.

On the hard sand road the advantage was in favor of the wide tires.

On the fair country road and on the deep mud road the advantage was with the service tires. In both of these cases the mud adhered to the spokes and fellies, and the wide tire wheels naturally accumulated a larger quantity than the service wheels.

On August 12 the carriage and limber with service wheels were taken into a grassy hollow, where the wheels sank from six inches to one foot in the sod and mud. Four teams were used at the start, but when the worst mud was reached the carriage stuck. It was necessary to use a block and fall to pull the carriage out, but the record was completed. Five teams were then hitched to the carriage and the wide-tire wheels fitted to it. The five teams pulled the carriage over nearly the same ground, but it was found that the mud was not so deep as in the first test, and a second trial was made with the wide tires, getting what appeared to be the same depth of mud as in the first test. These records were not considered by the board, as in this ground it was impossible to get exactly the same conditions in any two tests. The records are transmitted, however, as a matter of interest.

The next test, August 14, was made over dry plowed ground, the records of which are given under that date. In these tests the carriage with the limber was drawn by four teams and sank in the ground from one to four inches. However, the ground was dry and packed under the wheels. These tests were taken over the same ground and in both directions for each set of wheels, the results being in favor of the narrow tire. The tabulated record of these tests will show how accurately the tractograph was working. Attention is invited to the small difference in two directions. Going north, the difference is 2.95 square inches in favor of the service tires. Going south, the difference in favor of same tires is 2.85 square inches.

The final tests were made August 16, over the following different kinds of roads. Four teams were used in these tests:

Macadam road.—This test was made over about 300 yards, and conditions in both cases were as nearly the same as possible.

Mud road.—The wheels sank in this mud from 1 to 5 inches, but the mud was stiff and adhered only slightly to the wheels.

Cinder road.—This road was newly made, and had had the steam roller on it but once. The wheels sank in about 3 inches. It is thought the conditions were about the same as on an ordinary sand road.

Through the woods—sod.—This was over the sod in the woods, and the wheels sank in about 1 inch.

These records are given in tabulation under date of August 16, and show in each case an advantage in favor of the wide tires.

The carriage limber, gun, and tractograph weighed complete, with 5-inch tires, 8,500 pounds; with 4-inch tires, 8,484 pounds. The tractograph weighed about 35 pounds.

The springs used had been accurately tested, and for each spring one-half inch compression required 100 pounds pressure, so that in ese tests where 4 springs were used 1 inch on the record corresponds 800 pounds pull.

All areas were measured with the planimeter.

Kind of road.	Wide tires—5 inches.				Service tires—4 inches.			
	Area.	Length.	Average pull.		Area.	Length.	Average pull.	
Tests of August 7.	*Sq. in.*	*Inches.*	*Inches.*	*Pounds.*	*Sq. in.*	*Inches.*	*Inches.*	*Pounds.*
cadam	5.98	10.42	.5691	227.64	2.33	10.45	.2229	89.16
ep soft mud	10.36	4.45	2.328	931.2	9.62	4.45	2.1618	864.72
Test of August 11.								
cadam	1.78	10.37	.17164	137.31	3	10.48	.2862	228.96
adam with road brakes	(One wheel skidded.)				(Both wheels skidded.)			
n	4.52	3.35	1.35	1,080	5.09	3.40	1.497	1,197.6
ir country road, light and	14.21	13.45	1.0565	845.2	12.91	13.80	.9335	748.4
rd sand, small hill	5.78	5.90	.9796	783.68	5.9	5.72	1.0314	825.12
ep soft mud	15.64	10.87	1.4388	1,131.04	13.16	10.82	1.216	972.8
rd sand, road brakes on, oth wheels skidded	....	....	....	....	3.66	.97	3.77	3,016
Test of August 12.								
l with deep mud:								
First trial	7.14	3.48	2.05	1,640	....	....	....	....
Second trial	10.12	4	2.53	2,024	7.46	3.33	2.24	1,792
ne with good hill and ess mud:								
First trial	20	11.27	1.78	1,424	....	....	....	....
Second trial	19.77	11	1.797	1,437.60	21.57	11.78	1.83	1,464
Test of August 14.								
wed ground, going outh	18.36	6.62	2.7734	2,218.72	15.41	6.62	2.3278	1,862.24
me, going north over ame ground	20.41	7.75	2.6336	2,106.88	17.56	7.75	2.2658	1,812.64
Test of August 16.								
cadam road	3.24	16.07	.2016	161.38	3.91	15.91	.2458	195.64
d road	8.78	7.73	1.1358	908.64	9.76	7.80	1.2513	1,001.04
der road	7.35	7.64	.96204	769.63	7.89	7.44	1.10605	884.84
rough woods—sod	12.90	9.88	1.3056	1,044.48	13.84	9.64	1.4356	1,148.48

On September 27, 1902, the report was returned to the board, which, ıe to the relief of Major Taylor from duty at the Rock Island Arsenal, was now composed of Capt. L. M. Fuller, Capt. C. C. Jamieson, ıd Lieut. E. D. Bricker.

This board was instructed to make additional tests and to report a ırtnight in advance the probable date of such tests, in order that fficials of the Department of Agriculture and of the University of lissouri might be present. None of these officials accepted the inviıtion to be present at the tests, which were as follows:

The carriage used for these tests was siege howitzer carriage No. 32, ıodel 1893, with howitzer No. 4, model 1890. Limber No. 70 was tted with the tractograph.

To make the results comparative, the same carriage, limber, and ractograph were used for all the tests, changing the wheels only.

The tractograph was constructed as in previous tests when the four prings were used instead of two.

The springs were accurately tested and for each spring one-half inch ompression required 100 pounds pressure, so that 1 inch on the record orresponds to 800 pounds pull.

Plates 2 and 3 show the modified tractograph fitted to the limber.

The planimeter was used to measure all areas under the curves.

Four sets of wheels were used, viz: With 3-inch tires, with 4-inch tires, with 5-inch tires, and with 6-inch tires. The wheels were all 4-inch service wheels altered for the 3-inch, 5-inch, and 6-inch tires by changing the fellies and putting on tires of the proper width. Some delay was experienced in getting tire steel of the proper size, and the 5-inch tires were one-half inch thick, while all the others were five-eighths inch thick. For this reason, the 5-inch wheels were proportionally a little lighter than the others. The fellies all had the same general shape as the fellies of the standard service wheels.

The side plates were disks of galvanized iron and were fastened by screws, one on each side of the wheel. The object of these plates was to prevent the mud from packing between the spokes.

The track of the limber wheels and the carriage wheels is the same. The weights were as follows:

	Pounds.
Carriage, gun, and limber with tractograph, 3-inch wheels	9,325
Limber, with tractograph, 3-inch wheels	1,550
Carriage, with gun, 3-inch wheels	7,775
Weight on limber wheels, limbered up, 3-inch tires	4,060
Weight on carriage wheels, limbered up, 3-inch tires	5,265
Tractograph, about	35
3-inch wheels, each	296
4-inch wheels, each	332
5-inch wheels, each	349
6-inch wheels, each	420
Side plates with screws, each	7
4 sets (8 side plates)	56

In conducting these tests the wheels did not track in ruts previously formed unless expressly stated.

Three teams of horses were used on the macadam road, woods road, and cinder road. In the sandy loam and over plowed ground four teams were used. Five teams were used in deep mud and on the sod.

The tests extended over a period of ten days and on seven different kinds of roads. In addition, separate tests were made to show the results of tracking narrow tires in ruts made by wide tires, the results of tracking in ruts made by tires of same width, and the merits of side plates in deep mud.

No effort was spared to have the conditions the same during each set of tests, and such trials as were not comparative did not receive consideration by the board. All such rejected records are appended as a matter of interest.

Plate 4 shows the carriage before beginning the tests.

Macadam road.—The road was hard and smooth and the wheels made no impression. The pull increased slightly as the width of the tires increased. Plate 5 shows this road.

Cinder road.—This was a black cinder road, smooth and well rolled, the wheels making slight ruts. The 3-inch tires, record No. 3, struck a soft place near the edge of the road which was not encountered by the other wheels and which increased the average pull slightly, as shown by a comparison of the records. This road is shown in Plate 6.

Woods road.—This road was a track made by wagons through the woods and in some places showed old ruts. The ground was damp. The ruts varied in places and were 1 to 6 inches deep for the 3-inch and 4-inch tires, and 1 to 5 inches deep for the 5-inch, and 1 to 4 inches deep for the 6-inch tires. The results show the pull to decrease as the width of the tires increases. Plate 7 shows this road after 3-inch wheels had passed over.

Sod.—These tests were taken over a level stretch of good sod which was damp and spongy. The ruts were from 1 to 3 inches deep for the [illegible]-inch wheels and 1 to 2 inches deep for the others. The results show that the 5-inch tires and 4-inch tires pulled easier than the 3-inch and 6-inch. Plate 8 shows this ground after the 4-inch wheels had passed over.

Plowed ground.—This was a plowed field which had been packed to some extent by rains since being plowed. The ground was damp and the tests were made across the furrows. The depth of the ruts varied from 4 to 8 inches for the 3-inch wheels to 2 to 4 inches for the 6-inch wheels. No earth packed between the spokes and but little adhered to the fellies. The results show that the pull decreased as the width of the tires increased. Plate 9 shows the four tracks made during these tests.

Plowed ground (wheels tracking).—The 5-inch wheels were run in the tracks made by the 6-inch wheels in the preceding tests, the 4-inch followed and then the 3-inch, all in this same track. The pull was much less in these cases than when the wheels made a new track, although it will be observed that while the 4-inch tires pulled easier than the 5-inch, the 3-inch pulled harder than the 4-inch.

Sandy loam.—This was a loose, dry, sandy loam. The earth did not pack between the spokes nor adhere to the fellies. The 3-inch wheels sank from 8 to 12 inches, the 4-inch 6 to 12 inches, the 5-inch 5 to 10 inches, and the 6-inch 4 to 7 inches. In these tests the pull decreased rapidly as the width of the tires increased. Plate 10 shows the track made by the 3-inch wheels, plate 11 the track made by the 3-inch and 4-inch, the 3-inch being the right track.

Sandy loam (wheels tracking).—The 5-inch, 4-inch, and 3-inch wheels were run in the order given in the track of the 6-inch wheels made in the preceding tests. This ground packed readily and the results show a very marked decrease in pull required when tracking in ruts made by wider tires. Plate 12 shows the 6-inch ruts after the 5-inch, 4-inch, and 3-inch wheels had tracked through them.

Deep mud.—These tests were begun in a specially prepared stretch of ground. In the first trial, No. 27 with the 3-inch wheels, the horses floundered, the right wheel sank in a ditch at the edge of the road, and the carriage stuck. The five teams were unable to pull it out until the wheels were blocked up and boards placed under them. Plate 13 shows the carriage before its release.

An effort was then made to go through this same stretch with the 6-inch wheels with side plates, but the carriage again stuck. Plate 14 shows the carriage stuck in this trial. In this place there was no bottom to give a footing for the horses, and a new stretch of road was selected. This new stretch of road had a harder bottom and the mud, which was from 6 inches to 24 inches deep, was wet enough to stick to the wheels and pack between the spokes. Plate 15 shows the carriage just after it stuck. After going through with each set of wheels the same set went through again, tracking in its former ruts.

Plate 16 shows this road before beginning the series of tests. The ruts made by the 3-inch wheels, Plate 17, were from 6 to 24 inches deep; those made by the 4-inch wheels, Plate 18, were from 6 to 20 inches deep; those by the 5-inch wheels, Plate 19, were from 6 to 18 inches deep, and those by the 6-inch wheels, Plate 20, were from 6 to 18 inches deep. The closest scrutiny during this series of tests could detect no variation in the conditions, and the results are considered as accurately comparative as it is possible to obtain them. The results of these deep-mud tests show that when the mud is deep and sticky and packs between the spokes, the pull decreases as the width of the tire decreases, but that when the tire becomes too narrow and the depth of mud increases rapidly, the pull begins to increase.

Side plates decrease the pull to some extent in deep mud, although some mud adheres to them, but this advantage is not considered enough to outweigh their disadvantages, viz, that they are easily bent, wheels equipped with them are more difficult to handle, and they present a bad appearance. (Plate 21.)

The pull required going through deep mud is less when following up the track of a wheel with the same width of tire than when making a new track.

The above tests confirm, in all essential respects, the average of the combined results deduced in the tests made by the Experimental Station of the University of Missouri in 1897, by Studebaker Brothers in 1892, and by the British Association for Advancement of Science in 1902.

The tests by the board show:

1. On hard, smooth roads with no obstructions the tractive effort increases slightly with the width of tires.

2. On unmade roads, plowed ground, and sandy loam the tractive effort increases as the width of the tire decreases.

3. In deep mud which is sticky, adheres to the fellies and packs between the spokes, the tractive effort decreases as the width of the tire decreases until tire becomes too narrow and the depth of the ruts increases rapidly, when the tractive effort begins to increase.

4. In all cases wide tires leave the road in better condition than before they passed over it. The wider the tires the more marked is the improvement to the roads.

These results, in connection with the results of the tests previously referred to, show to the satisfaction of the board the following more general results.

* * * * * * *

1. The wide tires require slightly more tractive effort on hard, smooth roads and on good roads covered with dust or light slush. In all cases of roads or ground where the mud adheres to the fellies or packs between the spokes the tractive effort required is greater for wide tires.

2. That wide tires require less tractive effort than narrow tires on all other classes of grounds or roads.

3. That wide tires leave the road bed in better condition than before passing over.

* * * * * * *

NOTE.—In a few unimportant cases the results which have been obtained differ slightly, but for all classes of roads, important from a military standpoint, the general results are the same.

The question of determining the width of tires depends upon the object sought in the particular case under consideration.

In the case of siege gun carriages, the important point to be con-
ered is, in the opinion of the board, not what width of tires is most
antageous on the good road or average roads, but what width of
es is most advantageous under the most adverse conditions which
ht be encountered in an active campaign.

he approved programme for the first test given in second indorse-
nt O. O. file 25301–F, suggested that the different classes of roads
given a multiplier depending on the importance of getting through
ch a road in an actual campaign. The programme contemplated
als over five different classes of roads, but as these more extended
ts have been made over seven kinds of roads, the board has modi-
d these multipliers to correspond. In the first programme the multi-
lier for the deep-mud road was 10 out of 20. In the modified list
low the deep-mud road is given a value of 15 out of 35, which is pos-
bly a little low.

acadam road	multiplier	1
der road	do	1
oods road	do	2
d	do	3
owed ground	do	5
ndy loam	do	8
Deep mud	do	15

The tabulated results follow:

Record of wide-tire tests.

3-INCH TIRES.

[Weight of carriage, limber, gun, and tractograph, complete, 9,225 pounds; weight of side plates, 58 pounds.]

Kind of road.	Area under curve.	Length of record.	Average pull.		Remarks.
	Sq. in.	*Inches.*	*Inches.*	*Pounds.*	
Macadam road	1.77	10.8	0.17164	127.5	No ruts.
Cinder road packed first 50 yards up 3° grade.	7.25	10.25	.7078	666.84	Slight ruts; struck soft place beginning of test.
Woods road	12.8[illegible]	10.1	1.2257	990.36	Ruts 1 to 6 inches deep.
Sod, spongy	6.72	4.97	1.3821	1,091.60	Ruts 1 to 3 inches deep.
Plowed ground across furrows	20.67	9.86	2.0964	1,678.72	Ruts 4 to 8 inches deep.
Plowed ground across furrows; wheels tracking 6 inches, 5 inches, 4 inches, 3 inches.	18.87	10.25	1.8361	1,092.48	
Sandy loam, dry	26.84	9.82	2.7[illegible]	2,[illegible].84	Ruts 8 to 12 inches deep.
Sandy loam, dry; wheels tracking 6 inches, 5 inches, 4 inches, 3 inches.	12.38	10.12	1.2164	976.72	
Deep mud	15.90	5.90	2.6[illegible]	2,124.16	Ruts 6 to 24 inches deep.
Deep mud; wheels tracking in own ruts.	16.71	4.26	2.[illegible]	2,[illegible]	Ruts 8 to 24 inches deep.
Deep mud, with side plates	14.25	6.[illegible]	2.[illegible]	[illegible]	Ruts 6 to 18 inches deep.
Deep mud; not considered except in comparison with side-plate test above.	15.15	6.12	2.[illegible]	[illegible]	Ruts 7 to 18 inches deep.
Not considered.					
Deep mud	[illegible]	[illegible]	2.[illegible]	[illegible]	[illegible]
Deep mud	[illegible]	[illegible]	2.[illegible]	2,[illegible]	[illegible]

Record of wide-tire tests—Continued.

4-INCH TIRES.

[Weight of carriage, limber, gun, and tractograph, complete, 9,469 pounds; weight of side plat pounds.]

Kind of road.	Area under curve.	Length of record.	Average pull.		Remarks.
	Sq. in.	*Inches.*	*Inches.*	*Pounds.*	
Macadam road	1.8	10.45	0.1722	137.76	No ruts.
Cinder road packed first 50 yards up 3° grade.	6.28	10.87	.6056	484.48	Slight ruts.
Woods road	10.48	10.22	1.0254	820.32	Ruts 1 to 6 inches deep.
Sod, spongy	6.64	4.93	1.3468	1,077.44	Ruts 1 to 2 inches deep.
Plowed ground across furrows	17.6	9.95	1.7789	1,423.12	Ruts 3 to 7 inches deep.
Plowed ground across furrows; wheels tracking 6 inches, 5 inches, 4 inches, 3 inches.	13	10.05	1.2935	1,034.80	
Sandy loam, dry	24.12	9.50	2.5389	2,031.12	Ruts 6 to 1 inch deep.
Sandy loam, dry; wheels tracking 6 inches, 5 inches, 4 inches, 3 inches.	12.21	10	1.2210	978.80	
Deep mud	15.10	6.17	2.4473	1,957.84	Ruts 6 to 20 inches deep.
Deep mud; wheels tracking in own ruts.	14.20	6.15	2.3089	1,847.2	Ruts 7 to 21 inches deep.
Deep mud, with side plates	13.75	6.15	2.2357	1,788.56	Ruts 6 to 15 inches deep.
Deep mud; not considered except in comparison with side-plate test above.	13.34	5.9	2.2610	1,808.80	Ruts 6 to 18 inches deep.
Not considered.					
Deep mud	17.71	6	2.9516	2,361.28	Not comparative result; too deep and wet.

5-INCH TIRES.

[Weight of carriage, limber, gun, and tractograph, complete, 9,537 pounds; weight of side plat pounds.]

Kind of road.	Area under curve.	Length of record.	Average pull.		Remarks.
	Sq. in.	*Inches.*	*Inches.*	*Pounds.*	
Macadam road	1.9	10.54	0.1802	144.16	No ruts.
Cinder road packed first 50 yards up 3° grade.	6.49	10.17	.6381	520.48	Very slight ruts.
Woods road	10.02	10.35	.9855	788.40	Ruts 1 to 5 inches deep.
Sod, spongy	6.20	4.94	1.2551	1,004.08	Ruts 1 to 2 inches deep.
Plowed ground across furrows	17.68	10.07	1.6961	1,356.88	Ruts 2 to 5 inches deep.
Plowed ground across furrows; wheels tracking 6 inches, 5 inches, 4 inches, 3 inches.	14.95	10.18	1.4685	1,174.80	
Sandy loam, dry	19.66	9.45	2.0804	1,664.32	Ruts 5 to 10 inches deep.
Sandy loam, dry; wheels tracking 6 inches, 5 inches, 4 inches, 3 inches.	13.50	10.18	1.3261	1,060.88	
Deep mud	15.92	5.90	2.6983	2,158.64	Ruts 6 to 18 inches deep.
Deep mud; wheels tracking in own ruts.	15.17	5.96	2.5453	2,036.24	Ruts 7 to 19 inches deep.
Deep mud, with side plates	14.74	6.05	2.4363	1,949.04	Ruts 6 to 14 inches stuck; pulled out.
Deep mud; not considered except in comparison with side-plate test above.	12.36	6.04	2.0463	1,637.04	Rut 6 to 14 inches deep.
Not considered.					
Deep mud, with side plates	14.56	5.91	2.4636	1,970.88	Side plates torn off, bu at places; mud packe tween spokes where torn off.

Record of wide-tire tests—Continued.

6-INCH TIRES.

›f carriage, limber, gun, and tractograph complete, 9,821 pounds; weight of side plates, 53 pounds.]

‹ind of road.	Area under curve.	Length of record.	Average pull.		Remarks.
	Sq. in.	*Inches.*	*Inches.*	*Pounds.*	
road	2.76	10.20	0.2706	216.48	No ruts.
›ad packed first 50 p 3° grade.	7.22	10.30	.7009	560.72	Very slight ruts.
ıd	9.72	10.25	.9483	758.64	Ruts 1 to 4 inches deep.
ɣy	6.98	5.05	1.3821	1,105.68	Ruts 1 to 2 inches deep.
·ound across furrows	16.64	10.05	1.6557	1,324.56	Ruts 2 to 4 inches deep.
·ound across furrows, tracking 6 inches, 5 4 inches, 3 inches.	16.64	10.05	1.6557	1,324.56	
ım, dry	18.31	10.03	1.8255	1,460.40	Ruts 4 to 7 inches deep.
m, dry; wheels track- ·hes, 5 inches, 4 inches, ı.	18.31	10.03	1.8255	1,460.40	
l	16.97	5.83	2.9108	2,328.64	Ruts 6 to 18 inches deep.
l; wheels tracking in ɜ.	16.23	6.05	2.6826	2,146.08	Do.
l, with side plates	14.36	5.93	2.4211	1,936.88	Ruts 6 to 14 inches deep.
l; not considered ex- ·omparison with side- st above.	14.73	6.25	2.4714	1,977.12	Ruts 6 to 12 inches deep.
Vot considered.					
l, with side plates	17.23	5.85	2.9453	2,356.24	Stuck in mud; wheels blocked up and pulled out to one side.

Kind of road.	Multi-plier.	Three-inch tires.		Four-inch tires.	
		Average pull.	Weight given.	Average pull.	Weight given.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
road	1	137.50	137.50	137.76	137.76
ıd	1	565.84	565.84	484.48	484.48
ıd	2	980.56	1,961.12	820.32	1,640.64
	3	1,081.68	3,245.04	1,077.44	3,232.32
·ound	5	1,678.72	8,393.60	1,423.12	7,115.60
m	8	2,303.84	18,430.72	2,031.12	16,248.96
l	15	2,134.16	32,012.40	1,957.84	29,367.60
ıl weight	35		64,746.22		58,227.36

Kind of road.	Multi-plier.	Five-inch tires.		Six-inch tires.	
		Average pull.	Weight given.	Average pull.	Weight given.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
road	1	144.16	144.16	216.48	216.48
ıd	1	520.48	520.48	560.72	560.72
ıd	2	788.40	1,576.80	758.64	1,517.28
	3	1,004.08	3,012.24	1,105.68	3,317.04
·ound	5	1,356.88	6,784.40	1,324.56	6,622.80
m	8	1,664.32	13,314.56	1,460.40	11,683.20
	15	2,158.64	32,379.60	2,328.64	34,929.60
ıl weight	35		57,732.24		58,847.12

These results show an advantage in favor of the 4-inch tires, which advantage will increase if relative importance is given to the deep-mud class.

Attention is called to the relative poor showing made by the 3-inch wheels.

Plates 22 and 23 show tracings taken from tractograph records and are typical of the records from which the tabulations were made.

On November 23, 1903, the report was returned to the board for reconsideration, and the following was its action:

The board is of the opinion that the tests as made were most complete, and, moreover, agrees in every respect with the deductions drawn from these tests by the former board.

After a careful study of the above-mentioned tests and from personal experience of members of the board with heavy transportation under service conditions, the board is of the opinion that the most important point to consider is the width of tires that will be the most advantageous under the most frequent and adverse conditions which will be encountered in active service.

Omitting the use of multipliers and tabulating the average pull in pounds of the various widths of tire over different classes of roads, so as to show the relative merit of each width of tire under service conditions, we have the following table:

Tire.	Macadam road.	Cinder road.	Woods road.	Sod.	Plowed ground.	Sandy loam.	Deep mud.
3-inch	137.50	565.84	980.56	1,081.68	1,678.72	2,303.84	2,134.16
4-inch	137.76	484.48	820.32	1,077.44	1,423.12	2,031.12	1,957.84
5-inch	144.16	520.48	788.40	1,004.08	1,356.88	1,664.32	2,158.64
6-inch	216.48	560.72	758.64	1,105.68	1,324.56	1,460.40	2,328.64

The total load behind teams is not considered, as the only variable used was the wheels the increase in weight of which is, of course, the penalty of wider tires.

The most suitable tires for each kind of road is selected from the above table from those tires giving an average pull differing between limiting widths by less than 100 pounds.

The most suitable tire for—

Macadam road: 3, 4, 5, or 6 inch tires. Greatest difference between 3-inch and 6-inch tires equals 78.98 pounds. Pull increases as width of tire increases.

Cinder road: 3, 4, 5, and 6 inch tires. Greatest difference between 4-inch and 6-inch tires equals 81.36 pounds. Pull increases as width of tire increases from 4-inch tires up.

Woods road: 4, 5, and 6 inch tires. Greatest difference between 4-inch and 6-inch tires equals 61.68 pounds. Pull decreases as width of tire increases.

Sod: 3, 4, and 5 inch tires. Greatest difference between 3-inch and 5-inch tires equals 77.60 pounds. Pull decreases as width of tire increases up to 6 inch.

Plowed ground: 4, 5, and 6 inch tires. Greatest difference between 4-inch and 6-inch tires equals 98.56 pounds. Pull decreases as width of tire increases.

Sandy loam: 6-inch tires. Pull decreases as width increases.

Deep mud: 4-inch tires. Pull increases as width increases from 4 inches up.

From the above it [illegible] 3-inch tires are suitable for three kinds of roads—macadam, ci[illegible]r, sod; 4-inch tires are suitable for six kinds of roads—macadam, [illegible], woods, sod, plowed ground, and deep mud; 5-inch tires are sui[illegible]e for five kinds of roads—macadam, cinder, woods road, sod, and p[illegible] ground; 6-inch tires are suitable for five kinds of roads—macad[illegible]r, woods roads, plowed ground, and sandy loam.

From an examination of the [illegible]ove results it is evident that 3-inch tire is not adapted to siege ma[illegible]er [illegible]: 4-inch tire is equally as good as the 5-inch tire over similar ro[illegible] in addition is far superior to either 5 or 6 inch tires in deep [illegible]n, which is the most frequent type of road met with in actual ser[illegible]e; 5-inch tire is inferior to the 4-inch tire; 6-inch tire is superior to [illegible] 4-inch tire only on sandy roads, and inferior to the 4-inch in deep m[illegible].

The board is therefore of [illegible] opinion that the result shows an advantage in favor of 4-inch tires for siege material.

APPENDIX V.

ORT OF ORDNANCE BOARD ON RANGE FIRINGS WITH 12-INCH MORTARS.

(3 plates.)

THE ORDNANCE BOARD, U. S. ARMY,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, August 16, 1904.

R: 1. The board respectfully reports the results of firings made stablish data for range table of 12-inch B. L. mortar, model of , with smokeless-powder charges, pursuant to instructions given hird indorsement O. O. file 37438–28, May 24, 1902; third indorset O. O. file 37438–62, November 15, 1902, and O. O. letter, Novem- 5, 1903, 37438–198, the latter relating to drift of 1,050 pounds -iron solid shot for comparison with other projectiles. Previous orts with partial data were forwarded by letter September 22, 1903, by indorsement February 2, 1904, on O. O. 37438–198. The sent report includes the data given in the previous ones.

The firings for range have been made from 12-inch mortar car- e No. 193, model of 1896, Columbus Machine Company, altered utting additional teeth in the rack and chipping the top carriage ermit firing at an angle of 70°. The cast-iron racer of the car- e was cracked in firings with full charges at 70° elevation, as orted June 26, 1902, and was then replaced by a steel racer. Sub- ently the cast-iron top carriage was broken through the right nion and was replaced by a steel top carriage, which was used in mber of firings between December 18, 1902, and July 23, 1903. the latter date, due to the explosion of a shell in the bore, the tar was ruptured and the carriage damaged, requiring new equal- g pipes, cylinders, piston rods, and crosshead guides. Firings the carriage were resumed October 17, 1903, and have since been inued as required.

The data herewith comprise in general several series of firings different powders, to select the most suitable for the reduced ges and to construct the charge-velocity curves for the lots of der used, and range firings between 45° and 70° elevation with the ral kinds of projectiles in zones covering the field of fire from about 1,900 to 12,400 yards. The scheme of zones laid down is approximately as follows:

Zone.	Weight of projectile.	Muzzle velocity.	Limits of range.	Limits of elevation.
	Pounds.	*Ft. sec.*	*Yards.*	°
1	1,000-1,050	560	1,900 to 3,300	45 to 70
2	1,000-1,050	650	2,300 to 4,250	45 to 70
3	1,000-1,050	800	3,850 to 6,400	45 to 70
4	1,000-1,050	1,000	5,400 to 9,150	45 to 70
5	1,000-1,050	1,150	8,050 to 10,950	45 to 65
6	800-830	1,325	9,000 to 12,400	45 to 65

That is to say, the types of 1,000-pound projectiles are used with five different charges of powder from the shortest range up to their limit with full charge and velocity (1,150 feet per second), with limits of elevation between 45° and 70°, except that with the full charge the higher limit is 65°, and the types of 800-pound projectiles are used for an outer zone only to extend the range to their limit with full charge and velocity (1,325 feet per second), with limit of elevation between 45° and 65°.

4. This arrangement of zones it will be remarked is tentative only. The data presented should suffice for establishing the range tables with any other divisions deemed desirable by the artillery, or for supplying charges to cover zones satisfying local conditions, as has been suggested in a letter received from Captain Harlow, and may enable application to be made of cartridges put up in sections and the principles of widely overlapping zones, as proposed in Captain Landon's communication of April 5, 1903, O. O. file 37438-155.

5. The limit of 65° is placed upon the maximum angle for the two outer zones, while full charges are used (one for 1,000 and one for 800 pound projectile) for two reasons: 1, to reduce the strain on the carriage that would be caused with full charges and 70° elevation; and 2, the angle of fall for 70° is not required to secure deck penetration at the long ranges. In observing the drift curves for the nearer zones (plate 3) and their sudden departure toward the left at about 66° elevation, it appears that accuracy in direction at higher angles may be difficult of attainment. For this reason it may be deemed advisable to limit the maximum angles for zones 3 and 4 (as shown on the drawing) to 66°. This may be done without seriously affecting the sufficiency of the deck-penetrative power of the 1,000-pound projectile. It would however apparently require the introduction of an additional zone.

6. The inclosures herewith (in duplicate) comprise:

The firing records [not printed].

Ballistic data for 12-inch B. L. mortar range table, compiled from firing records.

Drawing showing actual ranges of projectiles in each zone, and drift curves for cast iron shell and torpedo shell.

Drawing of curves showing relation between angles of projection and ranges for various muzzle velocities, computed and actual, compared.

Drawing of curves showing relation between velocities and ranges for various angles of projection, computed and actual, compared.

The firing records will be more readily interpreted by stating their object, as follows:

Date.	Piece.	Number of rounds.	Object.
1902.			
September 12	12-inch mortar, No. 124.	68–76	Test of 5-inch R. F. smokeless powder, for reduced charges.
September 23	do	88–96	Test of 15-pounder R. F. smokeless powder, for reduced charges.
September 24	12-inch mortar, No. 138.	39–47	Observation of fall of projectile at short ranges.
October 10	do	61–64–71	Range with sphero-hexagonal powder, at 45° and 560 feet per second.
Do	do	72–75–77	Range with 5-inch R. F. powder, at 45° and 560 feet per second.
October 13	do	78–82	Range with 15-pounder R. F. powder, at 45° and 560 feet per second.
October 20	12-inch mortar, No. 124.	116–131	Retest of powders for charge-velocity curve.
1903.			
January 15	12-inch mortar, No. 158.	2–13	Test of 15-pounder R. F. powder, for varying charges and velocities, not to exceed a pressure of 28,000 pounds, this being the maximum limit assigned for the employment of 15-pounder powder in 12-inch mortar, model of 1890.
June 22–30	12-inch mortar, No. 152.	30–62–66–67	Test of 15-pounder R. F., and 12-inch mortar, smokeless powder, for charge-velocity curves.
June 30	12-inch mortar, No. 138.	97–105	Range firings in which only partial data were secured, not entered on tables of ballistic data.
July 2–8	do	106–148	Range firings, entered on tables of ballistic data, except rounds 145–148, for which data are incomplete.
July 11–21	do	149–153	Test action of fuse at short ranges.
July 21–23	12-inch mortar, No. 152.	81–92	Retest of powders for charge-velocity curves.
July 23	12-inch mortar, No. 138.	154–161	Range firings, entered on table of ballistic data, except round 161.
1904.			
March 4–April 9	12-inch mortar, No. 38.	88–97	Retest of powders for charge-velocity curves.
March 8–April 23	12-inch mortar, No. 124.	213–273 (ex. 241, 242)	Range firings, entered on table of ballistic data.
May 3–June 13	do	284–308	Do.
December 10	12-inch mortar, No. 152.	154–157	Charge-velocity test for 1,050-pounder capped cast-iron shot.
1904.			
January 16–18	12-inch mortar, No. 124.	173–187	Range firings, 1,050-pounder cast-iron shot, entered on last page of table of ballistic data.

With reference to the remark "Shell did not explode," frequently noted on the records when fused shell were fired, it will be stated that this refers to the apparent action as seen by observers usually placed near the firing point. Separate observations warrant the opinion that in a number of such cases the delay action of the fuse permitted the projectile to be so far submerged beneath the water as to render the explosion invisible if it did occur.

7. The projectiles used in the range firings on table of ballistic data have comprised—

	Weight, pounds.
Cast-iron mortar shell, sand filled	1,000
D. P. shell capped, charged with maximite and detonating fuse, as for service conditions, average about	1,030
Torpedo shell, charged with maximite and detonating fuse, or with asphalt to simulate high explosive charge, average about	1,030
Capped cast-iron solid shot	1,050
Cast-iron mortar shell, sand filled	800
Torpedo shell charged with asphalt to simulate high explosive charge, average about	825

The powder charges employed were varied to suit the weights of types of projectiles, as stated above, and also the weight of each projectile differing materially from the average, so as to give the same muzzle velocity to all projectiles fired in each zone. The variations of charge for this purpose will be particularly noted in the case of torpedo shell filled with asphalt, wherein the weights of 1,000-pound type vary from 1,015 pounds in round 273, April 23, 1904, to 1,030 pounds in round 213, March 8, 1904, and the weights of 800-pound type vary from 816 pounds in round 308 to 828 pounds in round 302, June 13, 1904.

The object in giving this uniform velocity for each zone has been for comparison of data with the different types of projectiles. In the preparation of range tables it is expected that uniform charges will be used in each zone and the resulting range deduced for the different types of projectiles.

8. The average weight, 1,030 pounds, for the heavy D. P. and torpedo shell, as used, was fixed by filling them with maximite and detonating fuse as for service conditions, and the average weight, 825 pounds, for the light torpedo shell resulted from filling them with asphalt having about the same specific gravity as indicated for the high explosive charge in filling the heavier shell.

9. The D. P. shell here used are a particular pattern, model 1893, modified. (See Ordnance Office drawing, June 12, 1896, and O. O. file 37514-4, returned to the Ordnance Office by seventh indorsement, December 20, 1902.) The capacity of this pattern is 944 cubic inches as compared with 1,211 cubic inches for the shell of model 1898. Shell of model 1898 constitute the principal supply on hand for service. In consequence of the reduced capacity of the D. P. shell model of 1893, modified, the charge of maximite contained is about 53 pounds, and the average total weight of shell, capped, 1,030 pounds. When this shell is charged with explosive D, pressed, the weight of charge becomes 46.75 pounds and the average total weight of shell, capped, 1,024 pounds. The weights of maximite cast, and explosive D, pressed, in shell charges are, respectively, 0.0566 and 0.0486 of a pound per cubic inch.

10. Assuming that explosive D will be used as the high explosive charge in service, the average weights filled and fused of 12-inch mortar D. P. shell, model 1898, and torpedo shell for the construction of range tables should be taken as follows, in lieu of the weights given for corresponding projectiles on page 14 of the publication "No. 1676, Table of U. S. Army Cannon and Projectiles, Washington, Government Printing Office, 1904."

T. steel shell (torpedo), reduced from 814 to 807 pounds.
T. steel shell (torpedo), reduced from 1,016 to 1,008 pounds.
Capped D. P. shell (steel), reduced from 827 to 824 pounds.
Capped D. P. shell (steel), reduced from 1,051 to 1,046 pounds.

It is to be noted that the weights of these shell in the publication referred to were based generally upon a weight of explosive charge taken as an average of explosive D and maximite.

11. In this connection attention is invited to the recommendation contained in the board's report of July 30, 1903, paragraph 19, regarding the explosion that occurred at round 161, 12-inch B. L. mortar, No. 138, in these firings using a cast-steel torpedo shell charged with

maximite, viz: That since the forged steel torpedo shell of present service pattern have occasionally shown evidence of deformation when fired with high pressures, their use should be restricted to a maximum velocity of 1,000 feet per second. This velocity can be obtained without exceeding a pressure of 25,000 pounds per square inch, which is considered a safe limit for the shell.

12. The results of these firings lead to the following conclusions:

(*a*) Two types of smokeless powder are needed for the service of the piece. The 15-pounder R. F. powder is suitable for reduced charges up to about 950 feet per second, the maximum pressure not to exceed 28,000 pounds in 12-inch mortar model of 1890. (See in this connection firing records rounds 2–13, 12-inch mortar, No. 158, January 15, 1903.) It is thought the dividing line between this and 12-inch mortar powder to be used for the heavier charges should be ordinarily at a charge giving about 950 feet per second velocity, in case such charge is needed. A smaller charge of 12-inch mortar powder might be employed, but in case of a lot of slow powder the unconsumed remnants blown into the mortar pit would probably prove objectionable.

(*b*) All points being considered, including accuracy and trueness of flight, the employment in service of the 1,000-pound type projectiles at a minimum range limit of about 1,900 yards, with 70° angle of projection, as shown for zone 1 on the inclosures herewith, seems fully justified. The necessity for using this zone of fire (1,900–3,300 yards) when zone 2 begins at 2,300 yards would probably not often arise, and the charges to be provided for it may be correspondingly reduced in number, but the board deems it important to retain this zone in any plans prepared, in order to utilize the fire of 12-inch mortars to the limit, approximately, of their shortest effective range.

13. Similar data remain to be secured for the 12-inch mortar model of 1886. This will be done under instructions contained in third indorsement O. O. 37438–109, October 25, 1902, which paper is retained, together with O. O. 23564–280, letter of the commanding general, Department of the East, October 28, 1902, instructing the commanding officer, Fort Hancock, to permit the commanding officer, Sandy Hook Proving Ground, to make the range firings from the mortar battery at Fort Hancock. The programme prepared for these firings comprises about 125 rounds, including tests of 15-pounder powder, to establish the charge-velocity curve for reduced charges with 1,000-pound projectiles, and of 5-inch R. F. powder for full charges with 1,000-pound and 800-pound projectiles.

CHAS. S. SMITH,
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The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(37438—250.)

BALLISTIC DATA FOR 12-INCH B. L. MORTAR-RANGE TABLE UND ORDNANCE BOARD PROGRAMME NO. 119.

These tables give ballistic data obtained in executing Ordnance Boa programme No. 119. Four azimuth instruments were used in ran observations. The longest base line was about 6,785 yards. T probable errors in measured ranges and angular deviations are sma The initial velocity was taken from a charge-velocity curve construct from data obtained with the lot of powder used. The velocity of t wind (corrected to true velocities) was taken from the continu record of the meteorograph shown on page ~~44~~, Circular D, Instrume Division, U. S. Department of Agriculture (Weather Bureau). T direction of the wind was taken from an indicator mounted near mortar and about 30 feet above the ground.

The D. P. shell used in these tests were capped. Both the D. and the torpedo shell up to round 161 were loaded with maximite, a contained a service detonating fuse. For all rounds after 161 the t pedo shell were loaded with asphalt.

Ballistic data for 12-inch B. L. mortar range table under Ordnance Board programme No. 118.

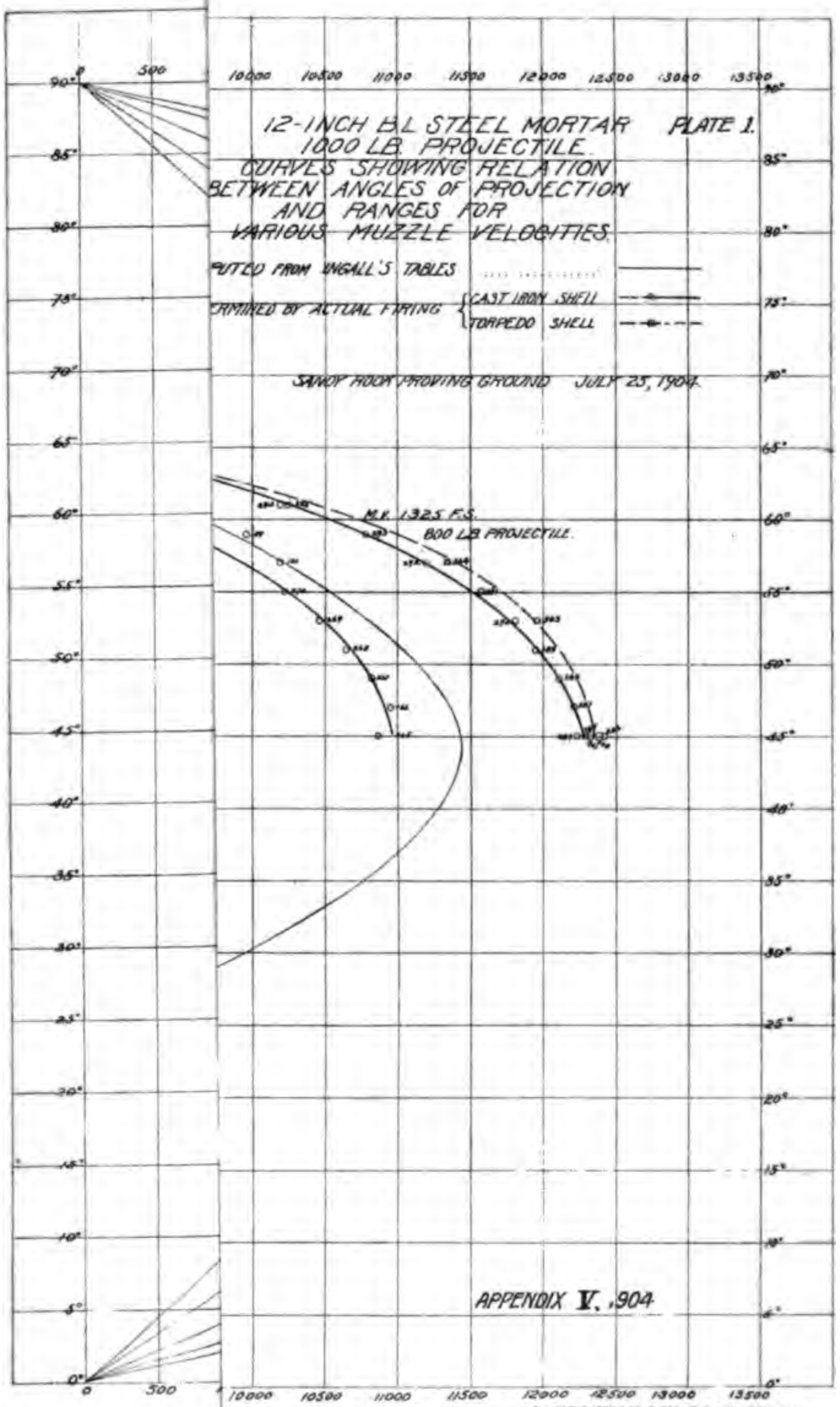
TABLE I.—FIRST ZONE.

Date.	No. of round.	Kind of shell.	Weight of shell.	Elevation.	Muzzle velocity.	Time.	Barometer at 32.	Thermometer.	Humidity.	Wind.			Time of flight.	Range.	Drift.
										θ + or −	Direction.	Velocity per hour.			
1903.			*Pounds.*	°	*Ft. sec.*					°		*Miles.*	*Seconds.*	*Yards.*	° ′
July 3	124	C. I.	1,000	45	570	1.28 p. m.	30.002	91	41	40+	R.	8.3	25⅘	3,271	2 7 R.
July 8	137	D. P	1,035	45	570(+)	10.25 a. m.	30.063	86	50	35+	R.	11.3	26⅕	3,320	2 30 R.
July 3	128	T	1,016½	45	570(+)	2.46 p. m.	30.002	91	41	40+	R.	9.6	26⅕	3,304	1 56 R.
July 7	129	C. I.	1,000	51	570	2.15 p. m.	30.118	87	42	60+	L.	5.5	28⅕	3,155	3 05 R.
July 8	138	D. P	1,031	51	570	10.42 a. m.	30.063	86	50	25+	R.	11.3	28	3,122	3 05 R.
July 7	130	C. I.	1,000	55	570	2.24 p. m.	30.118	87	42	60+	L.	6	29⅗	2,920	4 30 R.
July 8	139	D. P	1,030	55	570	10.57 a. m.	30.063	86	50	25+	R.	11.3	30	2,960	3 51 R.
July 3	125	C. I.	1,000	61	570+	1.52 p. m.	30.002	91	41	40+	R.	8.8	32⅖	2,789	4 0 R.
July 8	140	D. P	1,031	61	570	11.16 a. m.	30.063	86	50	30+	R.	11.3	32⅗	2,699	4 25 R.
Do	143	T	1,037	61	570(−)	2.24 p. m.	30.036	89	46	25+	R.	11.3	32⅘	2,718	3 30 R.
Do	144	T	1,021	61	570	2.49 p. m.	30.036	89	46	25+	R.	11.5	32⅘	2,656	3 30 R.
July 7	131	C. I.	1,000	65	570	2.36 p. m.	30.118	87	42	50+	L.	6	35	2,564	0 54 R.
July 8	141	D. P	1,035	65	570	11.26 a. m.	30.063	86	50	30+	R.	11.3	34	2,422	3 24 R.
July 7	132	C. I.	1,000	66	570−	2.45 p. m.	30.109	84	45	35+	L.	7.8	35	2,335	0 57 L.
July 8	142	D. P	1,035	66	570+	2.12 p. m.	30.036	89	46	25+	R.	11.3	34⅗	2,360	1 0 L.
Do	146	T	1,033	66	570−	3.10 p. m.	30.036	89	46	25+	R.	11.3	34⅘	2,386	2 24 R.
July 7	133	C. I.	1,000	67	570−	2.57 p. m.	30.109	84	45	30+	L.	7.4	34⅘	2,239	0 53 L.
Do	134	C. I.	1,000	68	570−	3.07 p. m.	30.109	84	45	25+	L.	6.9	34⅗	2,138	1 0 L.
1904.															
Mar. 8	213	T	1,030	68	560+	10.08 a. m.	29.555	39.77	83.54	19+	R.	18	33⅗	2,012	3 45 L.
1903.															
July 7	135	C. I.	1,000	69	570−	3.19 p. m	30.109	84	45	25+	L.	6.6	35	2,042	1 30 L.
Do	136	D. P	1,029	69	570−	3.54 p. m.	30.100	82	48	30+	L.	8.9	35	2,018	1 53 L.
July 3	126	C. I.	1,000	70	570	2.10 p. m.	30.002	91	41	40+	R.	7.8	34⅗	1,949	2 0 L.
Do	127	D. P	1,031	70	570−	2.21 p. m.	30.002	91	41	40+	R.	8.3	34⅘	1,879	3 15 L.
July 8	147	T	1,027	70	570−	3.20 p. m.	30.036	89	46	20+	R.	12.4	34⅕	1,928	3 20 L.

Ballistic data for 12-inch B. L. mortar range table under Ordnance Board programme No. 119.

TABLE II.—SECOND ZONE.

Date.	No. of round.	Kind of shell.	Weight of shell.	Elevation.	Muzzle velocity.	Time.	Barometer at 32.	Thermometer.	Humidity.	Wind.			Time of flight.	Range.	Drift.
										θ + or −	Direction.	Velocity per hour.			
1904.			*Pounds.*	°	*Ft. sec.*					°		*Miles.*	*Seconds.*	*Yards.*	° ′
March 8	214	C. I	1,000	45	650+	10.34 a. m.	29.557	40.14	83.02	14+	R.	18	29[illegible]	4,267	1 10 R.
Do	218	T	1,029	45	650+	11.18 a. m.	29.561	40.73	79.46	19+	R.	16	28[illegible]	4,223	1 45 R.
March 8	215	C. I	1,000	47	650−	10.43 a. m.	29.556	40.36	81.50	14+	R.	18	30[illegible]	4,258	2 20 R.
1903.															
July 2	106	C. I	1,000	49	652	1.50 p. m.	29.808	88	59	20+	R.	10.4	30	3,990	2 35 R.
1904.															
March 8	216	C. I	1,000	51	650−	10.53 a. m.	29.559	40.50	80.92	24+	R.	18	32	4,072	2 40 R.
1903.															
July 2	107	C. I	1,000	53	652	2.20 p. m.	29.808	88	59	30+	R.	10.4	33	3,918	3 21 R.
1904.															
March 8	217	C. I	1,000	55	650+	11.07 a. m.	29.560	40.60	80.10	19+	R.	16	34[illegible]	3,862	3 37 R.
Do	219	T	1,028	55	650−	11.30 a. m.	29.562	40.92	78.76	19+	R.	16	33[illegible]	3,798	3 10 R.
1903.															
July 2	108	C. I	1,000	57	652	2.55 p. m.	29.808	88	59	45+	R.	13.8	35	3,650	4 7 R.
Do	109	C. I	1,000	59	652 (−)	3.18 p. m.	29.800	90	57	40+	R.	13.8	35[illegible]	3,450	4 15 R.
Do	110	C. I	1,000	61	652	3.30 p. m.	29.800	90	57	30+	R.	13.8	37	3,460	4 24 R.
Do	111	D. P	1,031	61	650 (+)	4.00 p. m.	29.800	90	57	35+	R.	13.8	37[illegible]	3,350	3 40 R.
Do	112	T	1,032	61	650 (−)	4.13 p. m.	29.800	90	57	32+	R.	13.8	37	3,361	3 20 R.
July 3	113	C. I	1,000	63	652	10.12 a. m.	30.002	84	52	45+	R.	9.6	38[illegible]	3,363	1 4 L.
Do	114	C. I	1,002	65	652+	10.25 a. m.	30.002	84	52	45+	R.	9.6	38[illegible]	3,056	1 30 L.
Do	115	C. I	1,002	66	652	10.36 a. m.	30.002	84	52	35+	R.	9.6	38[illegible]	2,905	2 20 L.
Do	120	D. P	1,031	66	650	11.23 a. m.	30.002	84	52	30+	R.	9.6	38[illegible]	2,802	2 10 L.
Do	121	T	1,029	66	650−	11.40 a. m.	30.002	84	52	30+	R.	7.8	38[illegible]	2,876	2 45 L.
Do	116	C. I	1,003	67	652 (+)	10.50 a. m.	30.002	84	52	25+	R.	9.6	38[illegible]	2,810	2 20 L.
Do	117	C. I	1,003	68	652 (+)	10.58 a. m.	30.002	84	52	25+	R.	9.6	38[illegible]	2,687	2 18 L.
Do	118	C. I	1,003	69	652	11.06 a. m.	30.002	84	52	25+	R.	9.6	38[illegible]	2,512	2 18 L.
Do	119	C. I	1,004	70	652 (−)	11.12 a. m.	30.002	84	52	25+	R.	9.6	38[illegible]	2,412	2 18 L.
Do	122	D. P	1,029	70	650	11.50 a. m.	30.002	84	52	40+	R.	7.8	38[illegible]	2,323	2 45 L.
Do	123	T	1,035	70	650	11.56 a. m.	30.002	84	52	40+	R.	6.0	38[illegible]	2,298	2 15 L.



12-INCH B.L. STEEL MORTAR PLATE 1.
1000 LB. PROJECTILE.
CURVES SHOWING RELATION
BETWEEN ANGLES OF PROJECTION
AND RANGES FOR
VARIOUS MUZZLE VELOCITIES.

PUTED FROM INGALL'S TABLES		———
ERMINED BY ACTUAL FIRING	CAST IRON SHELL	—○—
	TORPEDO SHELL	-●-·-

SANDY HOOK PROVING GROUND JULY 25, 1904.

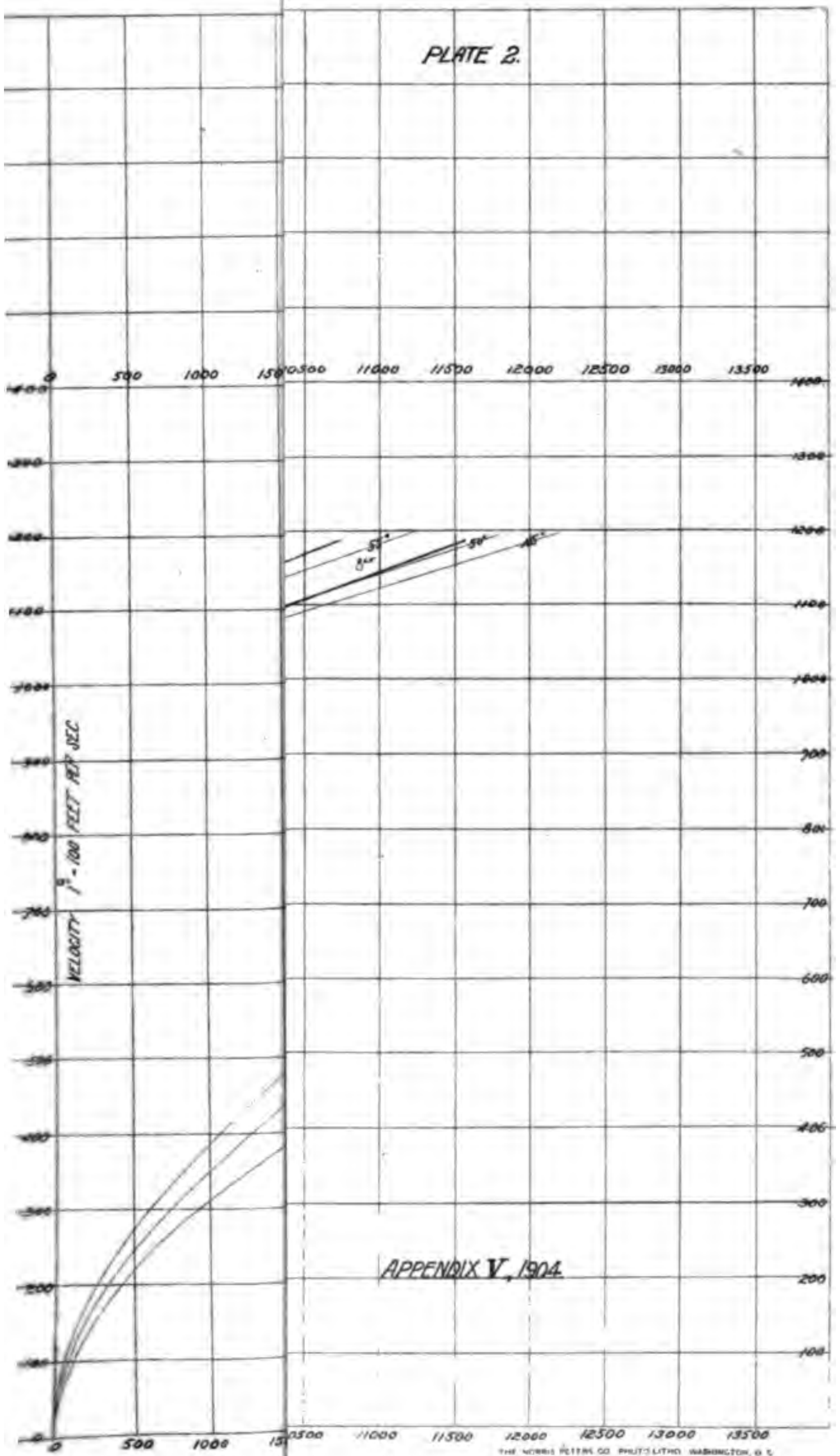
APPENDIX V, 1904

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

Partial ballistic data for 12-inch B. L. mortar, C. I. solid shot, capped.

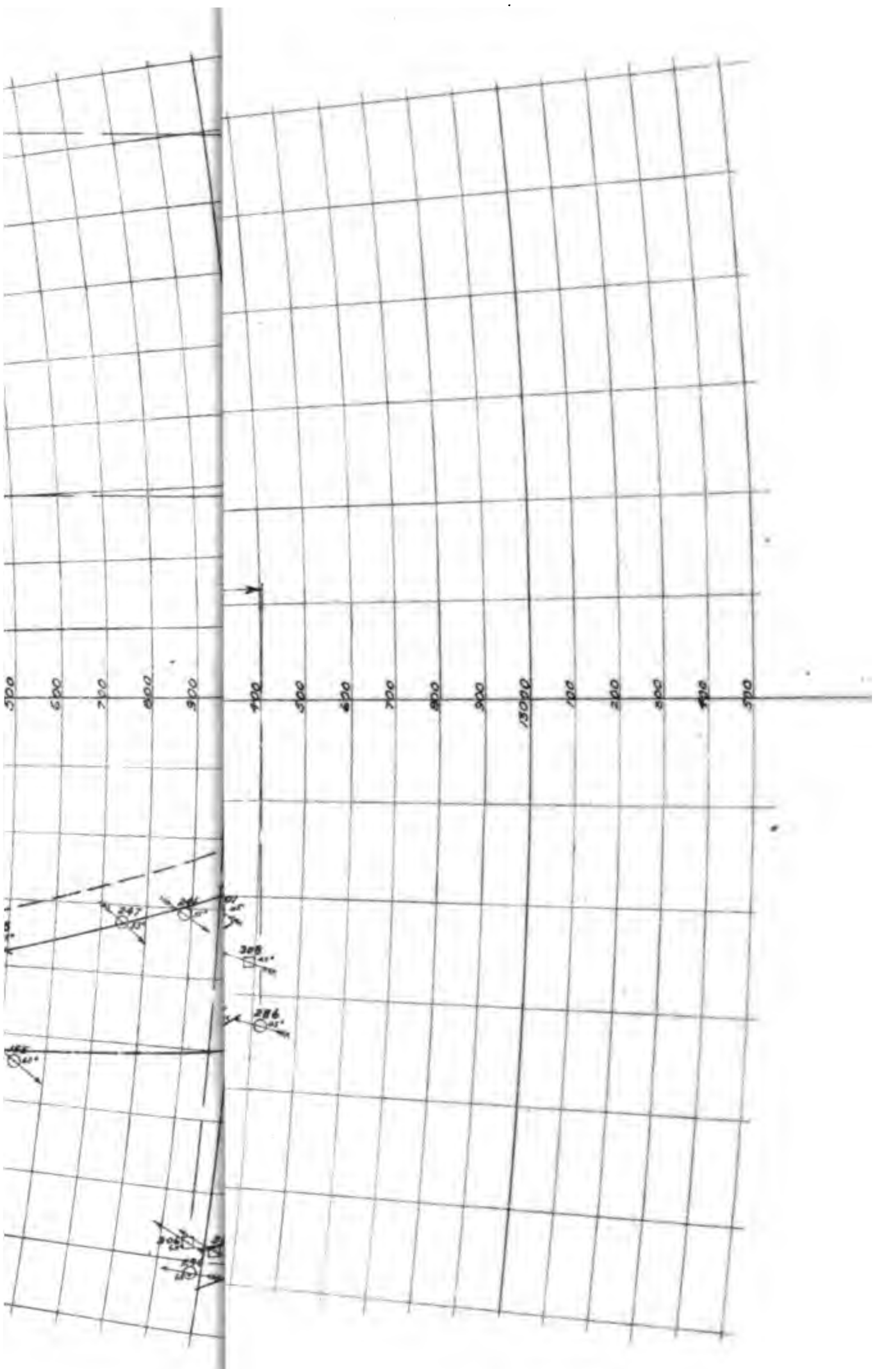
Date.	No. of round.	Round for day.	Kind of shell.	Weight of projectile.	Weight of charge.	Elevation.	Initial velocity.	Time of flight.	Wind data.			Time.	Barometer at 32.	Thermometer.	Humidity.	Range.	Drift.
									+ or −.	Direction.	Miles per hour.						
1904.				*Pounds.*	*Lbs. oz.*	°		*Seconds.*	°							*Yards.*	° ′
January 16	173	1	Cast-iron solid shot, capped.	1,050	13 11	70	560+	35	31−	R.	12	10.21 a. m .	29.986	31.1	75.25	1,796	5 50 L.
Do............	174	2		1,050	13 11	70	560+	33	36−	R.	16	10.42 a. m .	29.960	33.2	73.50	1,780	5 10 L.
Do............	175	3		1,050	13 11	70	560+	33	31−	R.	16	11 a. m	29.930	35	72	1,796	5 5 L.
Do............	176	4		1,050	13 11	70	560+	33	31−	R.	16	11.18 a. m .	29.912	35.6	69.91	1,788	5 20 L.
Do............	177	5		1,050	13 11	70	560+	33¼	46−	R.	16	11.39 a. m .	29.891	36.28	67.5	1,813	5 20 L.
Do............	178	6		1,050	18 6	61	650+	38	56−	R.	18	1.28 p. m .	29.760	38.46	66.46	3,396	0 40 R.
Do............	179	7		1,050	18 6	61	650+	37	56−	R.	12	1.49 p. m .	29.738	38.81	66.81	3,324	1 10 R.
Do............	180	8		1,050	18 6	61	650+	37	56−	R.	12	2 p. m	29.730	39	67	3,296	1 20 R.
Do............	181	9		1,050	18 6	61	650+	37	56−	R.	12	2.10 p. m .	29.729	38.34	67	3,280	1 35 R.
January 18	184	1		1,050	18 6	61	650−	37	31+	L.	16	11.04 a. m .	30.483	15	60	3,375	4 55 R.
January 16	182	10		1,050	52 2	65	1,150+	63	56−	R.	20	2.22 p. m .	29.728	37.55	100	7,860	1 30 R.
																	′ ″
Do............	183	11		1,050	52 2	65	1,150+	64	56−	R.	20	2.35 p. m .	29.726	36.69	100	7,845	2 0 R.
January 18	185	2		1,050	52 2	65	1,150−	63	26+	L.	18	11.29 a. m .	30.480	15.95	59.05	8,048	4 10 R.
Do............	186	3		1,050	52 2	65	1,150−	64	26+	L.	18	11.43 a. m .	30.477	16.42	58.58	8,096	4 0 R.
Do............	187	4		1,050	52 2	65	1,150−	63¼	16+	L.	18	11.58 a. m .	30.474	17	58	8,160	4 0 R.

PLATE 2.



APPENDIX V, 1904.

THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON, D. C.



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

APPENDIX VI.

REPORT OF ORDNANCE BOARD ON TEST OF FIELD MATERIAL.

(23 plates.)

THE ORDNANCE BOARD, U. S. ARMY,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, August 8, 1904.

SIR: 1. The board respectfully submits report of test of field material made pursuant to the following programme approved March 4, 1904, O. O. file 35524–153.

TEST OF 3-INCH FIELD GUN, MODEL OF 1902, AND PILOT CARRIAGE, MODEL OF 1902, ROCK ISLAND ARSENAL; AND OF ADDITIONAL BREECH MECHANISMS FOR FIELD GUNS, NAMELY:

(1) Stockett eccentric block mechanism fitted to 3-inch experimental gun of model 1902.

(2) Modified Stockett block and Tasker continuous-pull mechanism fitted to the same gun.

(3) Gerdom eccentric firing pin bushing, applied to 3-inch field gun, model of 1900, for short-recoil carriage.

(4) Gerdom eccentric block mechanism on 3.2-inch field gun converted.

(5) Stockett eccentric block mechanism on 3.2-inch field gun converted.

The guns will be mounted for firing tests, as follows:

On the pilot carriage, model of 1902, Rock Island Arsenal: 3-inch field gun, model of 1902, Gerdom breech mechanism, and the 3-inch experimental gun with special mechanisms designated 1 and 2, above.

On the short-recoil carriage, experimental, model of 1900: 3-inch gun, model of 1900, with modified Gerdom mechanism, and the two 3.2-inch converted guns, designated 3, 4, and 5, above.

AMMUNITION.

The 3-inch guns each use fixed ammunition (see Ordnance Office drawing, May 7, 1902); capacity of case 66.5 cubic inches, and projectile 15 pounds, with band 1.2 inches from base. The standard charge is nitrocellulose field gun powder of a weight suited to give 1,700 feet per second muzzle velocity with 110-grain (long) primer, in the 3-inch gun, model of 1902. Projectiles other than the standard may be used in tests other than firings for accuracy, as, for example, 3-inch cast-iron shell of Bethlehem manufacture, with band 1.55 inches from base. In such projectiles assembled in the standard cartridge case the charge will be regulated to give the same pressure as in firings with the standard ammunition, and care will be observed to adapt the band of projectile to fit the bore of gun.

The two 3.2-inch guns each used fixed ammunition (see Ordnance Office drawing October 24, 1894, revised to April 9, 1896); capacity of case 50 inches, and projectile 16.5 pounds, with band 1.75 inches from base. The standard charge is nitroglycerine field-gun powder of weight suited to give 1,450 feet per second muzzle velocity.

INSPECTION.

(1) The merits of the different breech mechanisms will be adjudged generally by the number of parts, their simplicity, strength, and certainty of action as a whole, during the tests; the ease with which they can be dismounted or assembled, in whole or in part, and particular note will be made regarding the ease of repair in case any part is broken or jammed in firing. Each breech mechanism will be photographed assembled on the gun, and with the parts separated, and a list prepared giving the names of parts corresponding to numbers on the photograph. Times will be taken as follows:

a. Dismounting the mechanism from gun, and tools required.
b. Dismantling the parts of mechanism, and tools required.
c. Reassembling the parts and placing mechanism on gun, complete.
d. Replacing firing pin, and other parts which may be adjudged necessary, as developed by the trials to be furnished as spare parts.
e. Dismounting the mechanism, if practicable, from gun without first opening the breech, and tools required.

(2) The 3-inch gun, model of 1902, and the 3-inch experimental gun of model 1902, will be star-gauged before firing tests of the gun, and at the conclusion of the trials or such other times as the board may direct.

(3) Photograph the 3-inch gun and carriage, model of 1902, with sights, including panoramic telescope and range quadrant, thereon complete. All firings with this equipment will be made with the complete service outfit unless otherwise specially directed by the board. In all firings with the model 1902 carriage the recoil will be recorded and special note made of any weakness, breakage, or defect in operation of any of the parts of the carriage or sights. Times in maneuvering the carriage will be taken; (*a*) to pass from extreme depression to extreme elevation, and the reverse; (*b*) to pass from one extreme in azimuth to the other.

FIRING TESTS.

(4) *Velocities and pressures* will be first taken to establish the standard times as may be necessary to insure the maintenance of the same.

(5) Ten rounds will be fired with each gun and breech mechanism, in preliminary firings to observe the working of the mechanisms.

Tests of 3-inch field gun and carriage, model of 1902.

(6) *Accuracy, deliberate fire.*—Fire two series of 10 rounds each, exclusive of sighting shots, for vertical target, at 2,500 yards range.

(7) *Rapidity, unaimed fire.*—Fire 10 rounds from loam platform, the trail having been set by one round.

(8) *Rapidity with accuracy.*—Fire 10 rounds at vertical target 2,500 yards, from loam platform, the trail having been seated and range secured by not exceeding two sighting shots.

(9) Repeat 8 from macadam, and also from rock platform.

(10) *Maintained rapidity with accuracy.*—Fire 45 rounds from loam platform, at 1,000, 2,500, and 1,000 yards targets, 15 at each, so placed that the trail must be shifted for each change of target.

(11) Fire about 100 rounds for endurance or sufficient to make in all 500 rounds fired from the gun tested under this programme.

Tests of 3-inch Stockett mechanism and of Stockett-Tasker mechanism, each with 3-inch experimental gun on model 1902 carriage.

(12) Repeat 7.

(13) Repeat 8, if deemed advisable by the board.

(14) Fire 50 rounds for endurance, if deemed advisable by the board, including at least one additional ten rounds for rapidity, unaimed fire.

Tests of Gerdom 3-inch eccentric bushing mechanism on short recoil carriage.

(15) Repeat 7.

(16) Fire 40 rounds for endurance, including an additional 10 rounds for rapidity, unaimed fire.

Tests of Gerdom and Stockett 3.2-inch mechanisms on short recoil carriage.

(17) Repeat 7.

NOTE.—Additional firing tests may be given these two mechanisms if deemed advisable by the board.

GENERAL TESTS OF CARRIAGE, MODEL OF 1902.

(18) Four kinds of platform will be used, viz: Loam, sand, rock, and macadam.

On each there will be fired 15 rounds at each of the three elevations, viz: Extreme elevation, zero elevation, extreme depression, 5 rounds being with the gun in its extreme position right, 5 rounds in mean position, and 5 rounds extreme left. In these tests the jump, departure from line of fire, and depth of trail and wheels will be noted. When necessary to move the trail, the power and time required will be noted.

(19) Fire 10 rounds with trail rigidly supported by an oak post.

SPECIAL TESTS.

To be applied to the 3-inch breech mechanisms only, unless otherwise directed by the board.

(20) *Excessive charges.*—Fire 10 rounds with increasing pressures, as follows: 2 rounds 35,000, 2 rounds 38,000, 2 rounds 40,000, 2 rounds 42,000, and 2 rounds 44,000 pounds.

In the last 2 rounds the cartridge cases will be annealed to within about 1 inch of the head, and the chamber of gun thoroughly cleaned and dried before the cartridge is inserted, with the object of causing the case to stick and testing the extractor.

with slides for firing from the short recoil carriage, experimental, model of 1900. The standard velocity, 1,450 feet per second, for the 3.2-inch gun, with 16.5 pounds projectile, is attained with a charge of 16 ounces smokeless (nitroglycerin) powder and 0.25-ounce igniter. The pressure with the lot of powder used is about 20,000 pounds per square inch. The cartridge case has a capacity of 50 cubic inches, and uses a short percussion primer. The igniter is placed in rear of the charge.

8. Star-gauging records have been taken, namely: For 3-inch B. L. rifle No. 7, model of 1902, to include round 372, and for 3-inch B. L. rifle No. 1, model of 1902, experimental, to include round 317 at the proving ground, after 69 rounds previously fired, making a total of 386 rounds. No appreciable expansion has occurred in either gun, as shown by the measurements to bottom of grooves and in the powder chamber, except about 0.002 inch at the forward end of the chamber in No. 1 gun. The wear of the lands amounts as a maximum to 0.004 inch, found in No. 7 gun near the commencement of the rifling.

9. Data relating to the several breech mechanisms and their maneuvering trials is collected in the following table:

ring pin bushin applied to 3-inch gun No. 1, model of 1900, short coil.

At Watervliet Arsenal, 25 rounds in proof of each of the 3.2-inch ms converted with Gerdom and Stockett mechanisms respectively.

GUNS AND BREECH MECHANISMS.

5. List of descriptive photographs of material (plates):

1, 2, 3. Stockett 3-inch breech mechanism on gun model of 1902, experimental; o. 1 shows Tasker firing handle in firing position.
4, 5, 6. Tasker 3-inch breech mechanism and firing attachments, gun model of 02, experimental, No. 4, shows Tasker firing handle in locked position.
7, 8, 9. Gerdom 3-inch breech mechanism, eccentric firing pin bushing, experiental, on gun model of 1900, short recoil.
10, 11, 12. Gerdom 3.2-inch breech mechanism experimental, on 3.2-inch gun nverted.
13, 14, 15. Stockett 3.2-inch breech mechanism experimental, on 3.2-inch gun nverted.
16, 17. Breech mechanism 3-inch B. L. rifle, model of 1902 (Gerdom).
18, 19, 20, 21. General views 3-inch Pilot carriage, model of 1902.
22. Panoramic rear sight with attached open sight.
23. Firing attachment on carriage, range quadrant, and recoil indicator.

6. The body of the 3-inch field gun, model of 1902, is made of nickeleel forgings, comprising tube, jacket, and locking hoop, assembled y shrinkage, and a slide band near the muzzle. The locking hoop is ined to the muzzle end of the jacket by a screw thread, and has an utting shoulder on the tube to connect the parts. The jacket has ide and guide rib surface on the underside in lieu of trunnions, to t the cradle of the long recoil carriage, and projections at the breech provide lugs for the hinge pin of the block carrier and for fastening e piston rod of the recoil cylinder of carriage. The principal data lating to the ballistics of the gun are:

eight of gun complete, with breech mechanism	pounds	836.5
ength of gun over all	inches	93.8
ngth of bore (28 calibers)	do	84.0
avel of projectile in bore	do	74.8
Rifling, 24 grooves, right hand-twist, increasing from 1 turn in 50 libers to 1 in 25 calibers at 12.52 inches from muzzle, thence uniform muzzle.		
epth of grooves	inch	0.03
idth of lands	do	0.10
owder chamber:		
Diameter, tapering	do	3.21–3.10
Length	do	10.98
ength of cartridge case	do	10.80
ength of cartridge, complete (shell)	do	21.90
eight of complete round	pounds	19.10
eight of projectile, filled and fuzed	do	15.00
eight of cartridge case, primed	do	2.3125
eight of black powder in percussion primer (long)	grains	110
eight of black powder igniter (front)	do	110
eight of smokeless powder charge (nitrocellulose)	ounces	26
pacity of cartridge case (powder spacing)	cubic inches	66.5
uzzle velocity	feet per second	1,700
ressure	pounds square inch	30,000

7. The 3-inch gun, model of 1902, experimental, is similar in conruction to the model 1902 gun, and each of the 3-inch guns, including e model 1900 gun, as modified for these tests, uses the same ammunion. The two 3.2-inch guns have the trunnions removed and are fitted

Breech mechanism 3-inch B. L. rifle, model of 1902.

10. The Gerdom breech mechanism (Plates 16 and 17) comprises 26 parts in the breech mechanism proper and 12 parts arranged for discharging the gun when in battery by means of the firing handle on the carriage (Plate 23), namely:

1. Hinge pin.
2. Hinge-pin spring.
3. Block carrier, with attached stop.
4. Latch bolt.
5. Latch-bolt spring.
6. Breechblock, with bushing screwed in fast.
7. Sear.
8. Sear spring.
9. Trigger.
10. Trigger spring.
11. Firing pin.
12. Firing-pin spring.
13. Cocking lever.
14. Hand-cocking lug.
15. Cover plate.
16. Cover-locking pins (2).
17. Operating lever.
18. Operating-lever pivot.
19. Operating-lever pivot key.
20. Operating-lever pivot key spring.
21. Operating-lever latch.
22. Operating-lever latch spring.
23. Operating-lever latch pin.
24. Extractor.
25. Extractor lever.
26. Trigger arm.
27. Trigger-arm pin.
28. Trigger-arm sleeve.
29. Firing shaft.
30. Firing-shaft bracket.
31. Firing-shaft bracket screw.
32. do.
33. do.
34. Firing handle.
35. Firing-handle spring.
36. Firing-handle pin.
37. Lanyard.

11. The block is of the eccentric screw type with two threaded and two flatted sectors. The rear part is cylindrical, with a reduced diameter which is threaded with the same pitch as the interrupted screw and fits into the carrier as a nut. The block is bored out to receive a bushing from the front and the firing pin and mechanism from the rear, placed eccentrically. The block recess is also bored eccentrically in the gun so that when the block is closed the firing pin is not opposite the primer in the cartridge case, but becomes central with the primer only when the block is rotated and the breech threads engaged. Bevel gear teeth are formed on the rear face of the block and mesh with those on the operating lever which is pivoted on the carrier immediately under the block. The rear end of the block is closed by a steel cover. In rotating the block, in opening, the cocking lever which is constrained to move between two cammed surfaces, one on the block and the other on the cover plate, withdraws the firing pin until it is caught by the sear. In rotating the block to close the breech, this lever compresses the main spring ready for firing. The piece can not be fired

il the block is fully closed and rotated, in which position the cock-
lever is free from the camming surface and can allow the full stroke
the firing pin.

2. The gun may be fired by lanyard attached in the eye of the trig-
, but is habitually fired by the handle and firing shaft on the car-
ge, which can be operated to fire only when the piece has returned
a safe position of recoil in battery. The firing handle and shaft are
ported in a bracket on the cradle and the trigger arm and sleeve
he right of the recoil lug on the gun. When the gun is in battery
firing shaft with square cross section enters the trigger-arm sleeve
l an outward pull on the firing handle revolves the shaft and engages
toe of the trigger arm to pull the trigger and fire the gun. The
ion of the firing-handle spring combined with the limited motion
wed the trigger arm by two set pins maintains the trigger arm in
rect position to avoid jamming of parts in the counter recoil of gun
er firing, and so that the trigger arm will be properly engaged for
ng again.

3. The extractor is composed of a ring which passes entirely around
rim of the cartridge case and guides which slide in grooves in the
ht side of the breech recess. The extractor lever is proportioned
s to act first as a wedge to start the empty case from its seat and
lever to throw it clear of the breech.

4. The breech is opened or closed by a single movement with the
rating lever. The mechanism can not be dismantled from the gun
hout first rotating the block. The successive steps in removing the
chanism by parts are then as follows: (1) Remove cover pins and
te. (2) Unscrew hand-cocking lug from firing pin. (3) Remove
king lever, firing pin, and spring. (4) Remove sear and sear spring.
Remove operating lever pivot key, pivot, and lever. (6) Unscrew
ck from carrier. (7) Remove hinge pin to dismount carrier. (8)
nove trigger and spring and latch bolt from carrier. (9) Dismantle
rating lever latch in order, viz, pin, latch, and spring.

5. The firing tests of this mechanism have comprised 14 rounds with
No. 3 and 372 rounds with gun No. 7, both mounted on the 3-inch
t carriage, model of 1902. The performance of the mechanism
generally good, including the trials by dust, rust, blow back, and
essive pressures, but at times it worked hard. No special repairs
re required to enable the mechanism to endure the test other than
stituting a new hinge pin and dressing the parts of the extractor
er the blow-back test at round 242 with gun No. 7. Opportunity
taken as the trials progressed to suggest changes for improvement
he mechanism to be embodied in guns under manufacture.

6. The changes which have been already decided upon include the
owing:

1) Shorten firing pin at screw end 0.1 inch to be 5.305 inches over
to more promptly withdraw firing-pin point within the face of
block on opening the breech.

2) Replace the two set pins that limit the movement of trigger arm
a single pin riveted to the trigger arm and working in a hole of
ficient size to allow the same limits of movement to the trigger
. The use of the two set pins or of the riveted pin alone renders
necessary the coil spring on firing shaft shown on earlier drawings.

3) Change profile of firing-handle spring.

in battery the turning of this shaft releases the sear through the intermediary of the tripping arm and sear tripping pawl.

23. The extractor moves in guides in the right side of the breech recess. It is operated by the extractor lever which pivots on the hinge pin and is tripped by the carrier on opening the block. The pivot hole in the extracting lever is elongated to produce at first a slow and finally a quick motion to eject the empty cartridge case.

24. The breech is opened or closed by a single movement with the operating lever. The carrier and parts of the mechanism, excepting the breechblock, can be removed directly from the gun without rotating the block, which is an advantage in case the block should be stuck fast. And the block is adapted finally to be unscrewed when exposed by using a wrench belonging to the carriage. A combination tool is furnished which is adapted to dismantling the various parts of the mechanism. The successive steps in removing the parts of the mechanism from the gun are as follows: (1) Remove screw and lift out the collet on gun body that holds the block stop in place, then remove the block stop. (The removal of the collet is not required if the breech is open.) (2) Remove split pin from hand cocking lug; then unscrew the latter about two turns of the thread and snap the firing pin to loosen the cocking lug, then unscrew the hand cocking lug and remove the cocking lug. (3) Remove hinge pin and then the carrier entire with operating lever, etc., attached. If the block is open the carrier and block will be disengaged by (1) Lift out the block stop; (2) release lock bolt and slightly turn block as in closing, then pull the sear and at the same time rotate the operating lever to allow the firing pin to move forward. To dismount the firing pin and spring, the pin must first be retracted to disengage the point from the seat in the front of the block to allow the firing spring sleeve to be unscrewed. Retract firing pin and place the combination tool (wrench) on the square section of the firing pin under the cocking lug, in which position it will hold the pin retracted, then unscrew the sleeve by striking on the wrench.

25. In assembling the block and carrier the firing pin must be cocked before attempting to close the operating lever or lock the block, in order to allow the toe of the operating lever pivot bolt to pass by the cocking lug. The combination tool furnished was not sufficient to perform all the operations as designed. The wrench jaws of the tool were spread in unscrewing the firing spring sleeve; the tool did not give sufficient leverage to unscrew the firing pin point, and the hinge pin being difficult to remove in this case required a drift and hammer for removal.

26. The firing tests of this mechanism have comprised rounds 11 to 16 and 201 to 242, inclusive, or 48 rounds with 3-inch B. L. rifle No. 1, model of 1902, experimental, mounted on the 3-inch pilot carriage, model of 1902; 69 rounds had previously been fired at Rock Island Arsenal.

In the commencement of the present trials the firing pin failed repeatedly to engage the sear, which appeared due to tendency of the firing pin bushing to unscrew. This bushing is assembled with a left-hand thread, and it is probable this defect would be obviated if a right-hand thread were used. The bushing was temporarily fastened in place by a set screw. Difficulty was also found in interference between the cocking toe and cocking lug which cock the firing pin. To remedy this the parts were dressed and metal removed from the hand cocking lug to allow the sear and safety latch to engage the firing pin with less throw than before. The remedy was not complete; interference continued between the cocking toe and lug, rendering the mechanism hard to operate. The removal of the hardened surfaces has also allowed undue wear to take place. At round 34 (proving ground series), while the block was being closed, the firing pin was released and struck the primer on the right edge. On retrial the same fault occurred. It was remedied for a time by placing a washer under the hand cocking lug, but after 13 rounds premature release of the firing pin again occurred.

27. The defects of the mechanism were reported by the Board in letter dated June 15, 1904, with an expression of opinion that this mechanism is not to be preferred to others on trial and further test of it is not necessary, and therefore, with the approval of the Chief of Ordnance, the trials were discontinued.

Breech mechanism (Stockett) 3.2-inch B. L. rifle, converted.

28. The Stockett mechanism on this gun (Plates 13, 14, and 15) is nearly a counterpart of that on the 3-inch B. L. rifle, model of 1902, experimental, previously described, except that being arranged for firing by lanyard only, all parts pertaining to the firing attachments on carriage are omitted. The 3.2-inch mechanism was manufactured before the 3-inch. The minor differences are a change in the form of sear notch and of notch for the safety latch, and the safety latch comprises an additional part (head) in the 3.2-inch mechanism.

29. The firing tests in these trials have comprised 20 rounds with the gun mounted on 3-inch short recoil carriage, model 1900, limited to test of the mechanism and rapidity of unaimed fire. No trouble was met with in the firings. The times taken in the maneuvering trials for dismantling the mechanism, etc., are given in the table, paragraph 9, for comparison with other designs.

Breech mechanism (Tasker) 3-inch B. L. rifle, model of 1902, experimental.

30. The United States Ordnance Company mechanism of Tasker design is shown on Plates 4, 5, and 6 herewith, and on four sheets of original drawings dated Office of the Chief of Ordnance, U. S. Army, February 17, February 23, February 24, and March 5, 1903. The design includes the breech mechanism proper, 25 parts, and the firing attachments on carriage for discharging the gun, 19 parts. This mechanism was adapted for trial to the same gun as the 3-inch Stockett mechanism previously described. The adaptation has apparently required no essential departure from the Tasker patent specifications No. 599482, February 22, 1898, No. 710124, September 30, 1902, and No. 751761, February 9, 1904, except in the extractor for which the Stockett design is retained, and the modification of the firing attachments on carriage to use the telescopic engagement of firing shaft already provided for on the gun. Parts common to the two mechanisms are all noted below. The list of parts is as follows:

1. Breechblock.
2. Firing mechanism housing.
3. Housing lock bolt.
4. Housing lock spring.
5. Housing lock cap.
6. Housing lock cap pin.

7. Firing pin.
8. Firing spring.
9. Firing spring sleeve.
10. Cocking lever.
11. Sear.
12. Trigger shaft.
13. Operating lever.
14. Operating lever latch.
15. Operating lever latch spring.
16. Operating lever latch pin.
17. Operating lever pivot.
18. Block carrier.
19. Block latch.
20. Block latch spring.
21. Hinge pin.
22. Hinge pin spring.
23. Hinge pin spring screw.
24. Extractor.
25. Extractor lever.
26. Firing handle, comprising handle with spring attached by 2 rivets, and hub attached by riveted hinge pin.
27. Firing shaft bracket.
28. Firing shaft stop.
29. Firing shaft.
30. Firing shaft latch.
31. Firing shaft latch trip.
32. Firing handle return spring.
33. Firing shaft return spring.
34. Firing shaft nut.
35. Firing shaft nut pin.
36. Firing shaft sleeve.
37. Trigger arm.
38. Trigger arm pin.

Nos. 21, 22, 23, 24, 25, 36, and 38 belong interchangeably with Tasker or Stockett mechanism.

31. The block is of the slotted-screw type, having four threaded and four plain sectors and a continuous pull-firing mechanism. The block recess is bored eccentrically in the gun. The carrier has a hub projecting into a central cavity in the block, and the latter revolves thereon in locking and unlocking the breech, being guided by a lug which engages in a groove cut in the carrier hub with a pitch corresponding to the threads on the block. This groove has a run out through which the guide lug must pass in assembling on disengaging the block and carrier. The carrier hub has a longitudinal chamber eccentric to the hub but concentric with the bore of gun, in which is inserted and secured by slotted sectors the housing containing the continuous pull-firing mechanism. This latter comprises the firing pin, firing spring and sleeve, the sear, cocking lever, and trigger shaft. When the block is rotated for opening the breech, and in all positions until it again nearly reaches the closed and locked position, the opening for the firing pin in the front face of the block is moved eccentrically and the firing pin, which always remains central to the bore, is prevented from moving forward to strike the primer, since the rear face of the hardened bushing in the front of the block is interposed in front of a shoulder on the pin. When the breech is closed the firing pin is free to go forward as soon as the sear is released. On pulling the trigger the firing spring is compressed and the sear finally released by the forward motion of the sleeve which trips the sear. On releasing the trigger the immediate return of the firing pin to its retracted position is insured by the reaction of the firing spring, which carries

the cocking lever to its initial position and restores the flange of the firing pin to the sear notch for renewed action on pulling the trigger. When the firing-mechanism housing is assembled through the slotted sectors in the carrier hub and turned to its locked position, the breechblock, carrier, and housing are completely interlocked for operation. Upon removal of the housing the block can freely move forward and off of the carrier hub; or, should the block be locked in the gun, the carrier, upon removal of the hinge pin, can be removed bodily to the rear and the mechanism completely dismantled, leaving only the block and the extractor on the gun. This is of advantage if from any cause the breech mechanism can not be opened by hand.

32. The mechanism provides positive abutting action of surfaces to limit the rotation of block in opening and closing, and an efficient block latch to prevent rotation of the block in the carrier while the block is open. The breech is opened or closed by a single movement with the operating lever. Bevel gear teeth are formed on the rear face of the block, and mesh with those on the operating lever, which is pivoted on the carrier below the block. The pivot of the operating lever requires no stay pin or nut, being effectually secured against accidental removal by assembling the firing-mechanism housing. The extractor is like that of the 3-inch Stockett mechanism.

33. The firing attachments on the carriage (see Plate 4, and Nos. 26 to 38, inclusive, Plate 6) provide for firing the gun within about 3 inches of its full return to battery, or as soon as the firing shaft is engaged in the sleeve which carries the trigger arm attached to the breech lug of the gun. The rotation of the firing shaft, which is accomplished by means of the firing handle to fire the gun, is constrained by two coil springs. The forward coil acts to return the shaft to its normal position as soon as it has been rotated far enough to fire the gun. The rear coil acts to return the firing handle to its normal position when pressure on the handle is released. This arrangement obviates danger of the trigger arm actuating the trigger shaft until the firing handle returns to its normal position and is again depressed, and also avoids interference between the trigger arm and projection on trigger shaft should the firing handle be depressed while closing the breech. In the safety position, as shown on Plate 4, the firing handle is folded on the shaft and interlocks with it, preventing rotation. This is the normal position for traveling or to prevent firing with a loaded gun. The original designs contemplate firing the gun exclusively by the attachments on carriage. The experimental mechanism has an additional arm on the trigger shaft with an eye for firing by lanyard. The retention of this arm, although it may be shortened somewhat, is deemed essential in any finished design, since without it and in case of failure of the firing attachments on carriage to operate it would be very difficult to fire the gun in any way.

34. The so-called firing unit in this design comprises three parts, viz, firing pin, spring, and sleeve. It is intended if any of these parts are broken to replace the entire unit by a spare one without having to take the broken one apart. This operation can be quickly performed, as shown by the table, paragraph 9. It requires 23 seconds, against 62 or 63 seconds to replace the firing pin or spring separately.

35. Substantial advantages embodied in the breech mechanism may be summarized as follows:

(*a*) A self-contained, continuous-pull firing lock, the firing pin being normally fully retracted and retained in its retracted position by the one simple firing spring, independently of any sear or other restraining device.

(*b*) The complete firing lock is readily removed and inserted from the rear, in either the closed or open position of the breechblock.

(*c*) The breech mechanism can be completely stripped while the breech is closed, leaving only the breechblock and extractor in the gun.

(*d*) All manipulations of dismantling and assembling breech mechanism and firing lock are performed by hand with ease and facility, no tool being required under ordinary conditions.

(*e*) The firing pin, though in a fixed position concentric with the bore of gun, can not move forward until the block (which is eccentric) is completely locked, bringing a cavity in line with the firing-pin head.

36. The firing tests of this mechanism have comprised rounds 1 to 10, 17 to 200, and 243 to 317, inclusive, or 369 rounds with 3-inch B. L. rifle, No. 1, model of 1902, experimental, mounted on the 3-inch pilot carriage, model of 1902. The firings called for by the original programme amounted to about 124 rounds, but advantage was taken of additional firings required to be made for the board revising the light artillery drill regulations, and test of cylinder for the pilot carriage, giving 45 inches recoil, to give this promising mechanism a more exhaustive trial.

37. Early in the test failure to fire was encountered both with the firing handle and by lanyard, and examination showed that the interior face of the front bushing in the block was burred by blows from the firing pin. The firing attachment on carriage also failed to work properly. After 21 rounds the mechanism was returned to Watervliet Arsenal, where the following changes were made:

(*a*) A new bushing with hardened rear face inserted in the front of the breechblock.

(*b*) Firing pin (which had been erroneously reduced near front end) restored to form by being fitted with a hard bushing, in which shallow depressions were cut to facilitate handling.

(*c*) A new and heavier tripping latch, with hardened tripping surface for the firing handle.

(*d*) Heavier and more efficient rotating springs for handle and shaft respectively.

(*e*) New dowels and stop screw and general refitting of firing attachments on carriage.

After return to Sandy Hook the firing-pin head was cut back 0.03 inch at point of engagement with sear, so that the firing pin not only can not go forward, but can not be tripped until the block is fully locked. After placing the renovated firing attachment on the carriage the parts required some fitting in place to secure satisfactory action. After the thirty-fourth round, however, when, owing to failure of the firing handle, 11 rounds were fired by lanyard, the adjustment of the firing attachment was made satisfactory, and no further trouble was found with it up to the 215th round in the rust test, when several failures to fire by the handle occurred. When the parts were cleaned, and for the remaining 54 rounds of the test, the operation of the firing handle was satisfactory.

38. Two series of 10 rounds each for greatest rapidity of unaimed fire were fired in 28 and 27.4 seconds, respectively, giving the best record of all the mechanisms for this test. The mechanism withstood satisfactorily the tests with excessive pressures, defective cases, dust, and blow backs. Before the blow-back test a hole 0.625-inch diameter was drilled in the lower side of the carrier midway between the two vent holes already there to provide an additional gas escape.

39. In the rust test the gun was left standing 68 hours after the breech had been dipped in the rusting solution for 20 minutes and the same solution had been applied to the firing attachments during the time with a sponge. The parts were well rusted. The breech was opened and 3 rounds fired with difficulty. Six minutes and 46 seconds were taken to oil and clean the parts. The total time occupied in the ten-rounds test, including cleaning, was 10 minutes 33.4 seconds. The last three rounds were fired in 9.5 seconds. When the mechanism was thoroughly cleaned the parts were found in good order, except the firing spring which required replacement. This spring had been used in 225 rounds and appears to have been chiefly damaged in the rust test.

40. Later in the trial trouble was developed with the continuous-pull firing mechanism in the breechblock. At round 240 the sear spring failed to hold the firing pin when pulled for firing; the firing spring was not compressed and the gun failed to fire. Examination showed the forward spiral of the firing spring to be set outward and interposed between the sear and firing pin, thus preventing the sear from taking proper hold on the flange of the firing pin. The spring was revolved in position on the firing pin to avoid this interference and afterwards about one-quarter turn of the forward spiral was cut off for the same purpose. Firings were continued to round 269 when the gun failed to fire on repeated trials, and examination showed the surface (corner) on the firing-pin flange to be so rounded by wear that it would not hold the sear. This bearing surface, with the flange of firing pin circular in form, was too small and utilized only about one-half of the available surface of the sear notch. The bearing surface on the pin was found, moreover, to have a very thin and insufficient case hardening. The defect did not endanger the handling of the gun, but simply prevented firing; it indicated (1) that the flange on the firing pin should be flatted for engagement of the sear and should be well hardened, and (2) that the firing spring should be made about 14.75 instead of 15 turns, so that if the end should become set it would not interfere with the action of the sear.

41. The flange of the firing pin was then altered at the proving ground by inserting a pallet of steel well hardened, with flatted surface tangent to the circle of the firing-pin flange for engagement by the sear. In this condition the firing mechanism housing with parts complete was forwarded to the Ordnance Office for examination. It will be remarked that the insertion of a pallet is not necessary in an original construction, since this portion of the firing-pin flange can be specially well hardened in the case-hardening process.

42. Since the return of the parts to the proving ground the continuous-pull firing mechanism has been operated 2,000 times to test its endurance with the alterations stated. The method was as follows: The block was placed with its weight resting upon and its front face in contact with a thin sheet of brass on smooth wood backing to simulate

the same resistance to the point of firing pin as the primer in actual firing. The mechanism in this position was pulled off 2,000 times, using the lanyard arm of the trigger shaft, and moving the brass strip to present a new surface for the pin to strike. The mechanism worked without failure during the test and at its end remained in good order, no appreciable wear being apparent on either the firing pin or sear at their surfaces of contact. The same sear was continued in use from the commencement of trials of the mechanism and the same firing spring that had been assembled at round 226 of the firing tests. Finally the mechanism, using the same parts, has since been tested in actual firing of 11 rounds from the gun with saluting charges and has functioned properly.

43. As the result of these trials the board finds that the breech mechanism proper of Tasker design, with changes in the continuous pull-firing lock, as indicated in the three preceding paragraphs, is simple, serviceable, and efficient, and worthy of adoption in service, provided it embodies a means of firing by lanyard in addition to firing attachments on the carriage. In future constructions, however, it would appear advisable to increase somewhat the strength of the sear spring by widening it about 0.05 inch and thickening it about 0.02 inch, and also to increase somewhat the thickness of the forward part of the casing that incloses the firing pin; but the latter change should not be made to endanger the resistance of the breechblock to radial compression.

44. Regarding the firing attachment on carriage the board finds it is excellent in principle and the tests show it can be made to perform well, but the complexity of design and the nice adjustment of parts required, which also leaves little room for wear of parts in service, make it desirable to secure a better design. The attachment for the 3-inch B. L. rifle, model of 1902 (Gerdom mechanism), is fairly efficient, but lacks the safety feature desirable for locking a gun which may have been loaded and is to be left standing for some time, or is to be moved, etc., before firing. The following are regarded as important features to be embodied in a design:

(*a*) To enable the gun to be fired when within a distance of 3 inches from the position in battery. To this end the telescoping firing shaft and sleeve now employed seem well adapted.

(*b*) To avoid all interference or jamming of parts in the counter recoil of the gun or in opening and closing the breech, in whatever position the firing handle may be held.

(*c*) To include an efficient means of locking the firing attachment against accidental discharge.

Breech mechanisms, 3-inch B. L. rifle, model of 1900, modified.

45. The Gerdom breech mechanism, with eccentric firing-pin bushing (Plates 7, 8, and 9), adapted for firing from the short recoil carriage, model of 1900, and by lanyard only, comprises 25 parts, as follows:

1. Breechblock.
2. Firing-pin sleeve (eccentric).
3. Firing pin.
4. Firing-pin spring.
5. Hand-cocking lug (cap).
6. Cover plate.

7. Cover-locking pin (split).
8. Operating lever.
9. Operating lever latch.
10. Operating lever-latch spring.
11. Latch pin.
12. Operating lever pivot.
13. Operating lever-pivot key.
14. Cocking lever.
15. Sear.
16. Sear spring.
17. Latch bolt.
18. Latch bolt spring.
19. Trigger or lanyard pull.
20. Trigger spring.
21. Extractor lever.
22. Carrier.
23. Hinge pin.
24. Extractor.
25. Carrier cover or hood.

46. The alterations made in the continuous-pull breech mechanism of 3-inch B. L. rifle No. 1, model of 1900, for short recoil carriage to adapt it to the present design of eccentric firing-pin bushing are shown in detail on drawing dated Watervliet Arsenal, August 18, 1903. The object sought is to provide an eccentric position of the firing pin on closing the block and to dispense with eccentric boring of the breech recess. The block is bored out eccentrically to receive the bushing, and the cavity containing the firing pin and spring is bored eccentrically in the bushing, so arranged that when the block is first closed the firing pin is not opposite the center of the primer, but is brought to that position by rotating the block to the locked position. The bushing is threaded in the block cavity near its forward end, and is restrained by the cocking lever from turning with the block. In rotating the block to open the breech the block revolves about the bushing and throws the firing pin away from the axis of the gun. The firing pin is retracted by the action of the cocking lever on its camming surface, and the bushing is at the same time retracted one-thirty-second of an inch from its flush position, with the front face of the block corresponding to one-quarter turn of the thread on the bushing. The bushing is dismounted from the block by unscrewing from the rear after removing the cover pin (one only is used in this mechanism) and plate, the hand-cocking lug, cocking lever, firing pin and spring, and the sear.

47. The firing tests of this mechanism to date comprise rounds 352 to 520, inclusive of 169 rounds with 3-inch B. L. rifle No. 1, model of 1900, short recoil. The records of the first 56 rounds, fired at the proving ground between June 18 and August 12, 1903, to test the new cartridge case with 66.5 cubic inches capacity and including the first blow-back test of the mechanism, were forwarded to the Ordnance Office with indorsement of August 20, 1903, on O. O. file 35306–224. Ten rounds were fired in test of shrapnel September 25–26, 1903. Additional firings to a number of 103 rounds were fired under the present programme. The gun was returned to Watervliet Arsenal in May to be fitted with another type of breech mechanism involving a retracting bushing proposed by Mr. Gerdom. Through an oversight the maneuvering trials of this mechanism were not made before the gun was sent away, hence the results are not available to be placed in he table paragraph 9 with those of other mechanisms tested.

48. Including the 169 rounds fired, the following incidents of the trials relating to the mechanism are to be noted. After round 355 the sear was found to be broken, due apparently to erroneous dimensions; it was replaced, and worked satisfactorily afterwards. At round 372 failure to fire was observed, and similar failures occurred at intervals throughout the tests, indicating weak action of the firing pin. After the first blow-back tests, rounds 406 and 407, the operating lever was slightly sprung, and the latch failed to hold the block closed. The false impression of the firing pin on primer, noted on the record in the examination preceding round 418, is not explainable on any ground as due to faulty action of the mechanism. The first test for rapidity, unaimed fire, rounds 428–435, was stopped after 8 rounds by losing the latch pin from the operating lever. In the second trial the 10 rounds were fired in 29.8 seconds. In the dust test, rounds 468–477, it was necessary to use a piece of wood as a lever to open the breech after firing the first round, requiring 90 seconds; the remaining 9 rounds were fired normally, the total time occupied being 226 seconds. At round 488 the cover-plate pin dropped out, due to looseness of fit, which was readily repaired. At the first round of the second blow-back tests (499) the firing pin was bent and upset, requiring the mechanism to be sent to shops for repair. The second round left the mechanism in good order. In the rust test, rounds 511–520, which concluded the trials, in attempting to fire the first round it was found that the firing pin would not move forward. The mechanism was dismounted and oiled, and then worked properly, the total time being 202.6 seconds.

49. In general no serious defects were developed in the trials if exception be made to the difficulty of working in the rust and dust tests, due, it is thought, to the liability of the eccentric bushing to be clogged in its movement by foreign matter. The end of this bushing, which is exposed in the front face of the block, at one time during the trials was slightly burred on the edge and required rounding in the corner to facilitate its working. The board finds that this mechanism with eccentric firing-pin bushing is not a type deserving of special commendation.

CONCLUSIONS RESPECTING BREECH MECHANISMS.

Reference will be made to the preceding accounts of the several mechanisms for remarks concerning them. The board is of the opinion that the Gerdom mechanism for 3-inch guns, model of 1902, with the changes indicated, which it is understood have been already inaugurated for guns under manufacture, is a safe type and fitted to render efficient service, but it may with advantage be replaced with a simpler type, involving less care in manufacture and probably also less expense, in future constructions. The board is further of the opinion that the United States Ordnance Company breech mechanism, Tasker design, possesses on the whole marked advantages over those tested herewith and is suitable for adoption in service with the changes indicated as necessary by the trials. The firing attachment on the carriage pertaining to this mechanism is not so meritorious and improvements therein are desirable.

3-INCH PILOT CARRIAGE, MODEL OF 1902.

50. General views of the carriage with gun complete are shown in plates 18, 19, 20, and 21. Plate 22 shows the panoramic rear sight and 23 shows the range quadrant to be used for indirect fire in connection with the panoramic sight. The firing tests of the carriage, in addition to 84 rounds reported from Rock Island Arsenal, have included 703 rounds at the proving ground with three different guns carrying four breech mechanisms, which were repeatedly interchanged. The serial numbers of the rounds fired from the carriage are given on the accompanying firing records for the guns, as follows:

	Rounds.
3-inch gun No. 3, model of 1902	1 to 14
3-inch gun, model of 1902, experimental, Tasker breech mechanism	15 to 24 66 to 70 125 to 235 309 to 376 499 to 542 644 to 674
3-inch gun No. 7, model of 1902	25 to 59 71 to 124 236 to 308 377 to 456 543 to 643 675 to 703
3-inch gun, model of 1902, experimental, Stockett breech mechanism	60 to 65 457 to 498

The results of the trials of the pilot carriage and its equipment, indicating desirable modifications for the service material under manufacture, have been reported as the trials progressed. The difficulties met with have related to the recoil system and some minor parts, and may be summarized from the firing records and previous correspondence as follows:

51. The cylinder furnished with the carriage was designed for 48 inches length of recoil and the counter recoil buffer gave somewhat greater clearance than needed. The frequent interchange of guns on the carriage and the lack of exact alignment of the cylinder fastening to lug on gun in some cases caused friction at the rear end of cradle and resulted during the earlier trials in bending the cylinder and piston rod. Roughness and lack of uniformity of diameter on the piston rod causing unequal bending in the stuffing box was found and also binding and chattering of the springs on the cylinder, due to sharp inner corners of springs. Finally the action of the system was seriously obstructed by soft metal which was found in the cylinder and counter-recoil buffer recess. These causes chiefly led to generally unsatisfactory action of the recoil system up to round 413, when they were remedied.

52. The liquid in cylinder was changed several times to avoid a somewhat excessive recoil and also too free return of the gun into battery with loose-fitting buffer. At round 142 a mixture of equal parts of glycerin with water was substituted for hydrolene oil. The effect was to reduce the recoil about 0.25 inch, or from 48.375 to 48.125 inches. At round 148 a mixture of 80 parts glycerin with 20 of water was substituted, reducing the recoil to about 47 inches. At round 196 a mixture with two-thirds glycerin was tried, giving about 47.5 inches recoil. Hydrolene was first used after round 220 with the new piston rod and buffer, but was replaced at round 236 by the mixture of equal parts glycerin and water. The recoil was reduced from

about 48.6 to about 48.2 inches. This mixture was then continued in use to round 643, when the new cylinder designed for 45 inches recoil was assembled.

53. At round 118 the cover plate at rear end of cradle was started by the shearing of 4 of the 7 rivets that held it. A new plate was made and assembled with 13 rivets as required for the service design. The piece afterwards remained fast, although some indications of giving were observed at round 643. As a result of the earlier tests slight changes were recommended in the opening of piston rod and head of buffer to facilitate entrance of the buffer without marring, also to round the corners at front shoulder of piston rod to enable the rod to be assembled without changing the packing in the stuffing box.

54. From rounds 414 to 643, using the 48-inch recoil cylinder, the action of the recoil system was generally satisfactory, except failure to fully return to battery at maximum elevation, due apparently to weakness of the counter recoil springs. These firings included the dust test, rounds 509–518, and the rust test, rounds 634–643. In the latter the elevating and traversing gear did not take rust. Other exposed parts, including the guides, were well rusted, and the only effect observed was to reduce the recoil about 1 inch.

55. The present tests were concluded by firing 60 rounds (604–703) with the new recoil cylinder designed for 45 inches recoil and the piston rod and buffer previously used. Three new counter recoil springs were also assembled, and hydrolene oil was used in the cylinder. The trials included 15 rounds each on loam, macadam, sand, and rock platforms, fired 5 each at zero elevation, extreme elevation, and extreme depression, with gun in central position. The results obtained for action of carriage and steadiness of fire are generally satisfactory. The recoil of gun on carriage is uniform and averages nearly 45 inches, although slightly exceeding that amount when the trail is so supported as to prevent any considerable carriage recoil. The maximum gun recoil is about 46 inches, obtained in firings at maximum elevations on hard, loam, and rock platforms. The deficiency in counter recoil of gun observed at extreme elevations, amounting in extreme case to 1.5 inches, was obviated by removing the filling plug with gun at extreme elevation and allowing the small amount of warm oil that would be forced out in that position to escape.

56. The strength of the counter recoil springs was measured by resting the spring on end upon a platform scale with a piece of round bar in the coil to avoid buckling, and compressing the spring from the top under a drill press, meanwhile tapping the coil to prevent friction on the core bar. The weight was read from the scale for each compressed length measured. Eight springs in all were used in the trials in sets of three, viz:

Springs Nos. 31, 50, and 97, in rounds 1 to 183; Nos. 31, 11, and 44, in rounds 184 to 643, and Nos. 47, 48, and 49, in rounds 644 to 703. The first five had been in use at Rock Island Arsenal. The last three were new springs received from abroad through the New York Arsenal.

Spring No. 31 was tested after round 118 and again after round 413. It sustained a weight of 516 pounds when compressed to a length of 22.375 inches in the first test and 22.29 inches in the second, maintaining nearly the standard 23.33 inches, and showing no appreciable loss under 296 rounds.

) *Rapidity, unaimed fire.* Fire 10 rounds from loam platform, trail having been set by one round.

) *Rapidity with accuracy.* Fire 10 rounds at vertical target 2,500 la, from loam platform, the trail having been seated and range red by not exceeding two sighting shots.

) Repeat 8 from macadam, and also from rock platform.

0) *Maintained rapidity with accuracy.* Fire 45 rounds from loam form, at 1,000, 2,500, and 4,000 yards targets, 15 at each, so placed the trail must be shifted for each change of target.

1) Fire about 100 rounds for endurance or sufficient to make in 00 rounds fired from the gun tested under this programme.

of 3-inch Sheslett mechanism and of Sheslett Tudor mechanism each with 3-inch experimental gun in model 1902 carriage

) Repeat 7.

) Repeat 8, if deemed advisable by the board.

) Fire 50 rounds for endurance, if deemed advisable by the board, ding at least one additional ten rounds for rapidity, unaimed fire.

Tests of Gordon 3-inch eccentric locking mechanism in short recoil carriage

) Repeat 7

) Fire 40 rounds for endurance, including an additional 10 rounds apidity, unaimed fire.

Tests of Gordon and Sheslett 3-inch mechanisms in short recoil carriage

) Repeat 7.

TE. Additional firing tests may be given these two mechanisms emed advisable by the board.

GENERAL TESTS OF CARRIAGE MODEL OF 1902

) Four kinds of platform will be used, viz: loam, sand, rock, macadam.

each there will be fired 15 rounds at each of the three elevations, Extreme elevation, zero elevation, extreme depression, 5 rounds with the gun in its extreme position right, 5 rounds in mean on, and 5 rounds extreme left. In these tests the jump, departure from line of fire, and depth of trail and wheels will be noted. necessary to move the trail, the power and time required will ted.

) Fire 10 rounds with trail rigidly supported by an oak post.

SPECIAL TESTS

be applied to the 3-inch breech mechanisms only, unless other directed by the board.

Excessive charges. Fire 10 rounds with increasing pressures, lows: 2 rounds 35,000, 2 rounds 38,000, 2 rounds 40,000, 2 s 42,000, and 2 rounds 44,000 pounds.

he last 2 rounds the cartridge cases will be annealed to within 1 inch of the head, and the chamber of gun thoroughly cleaned ried before the cartridge is inserted, with the object of causing se to stick and testing the extractor.

The injuries to the felloes of the wheels noted on the firing record, a result of the road test at Rock Island Arsenal, have not bee extended or developed further weakness in the firing tests.

60. The bracket supporting the rear sight became very loose aft 244 rounds, due to loose rivets. The rivets were then carefully tigh ened and the bracket did not again become loose. The panoramic re sight, the front sight, and the quadrant sight supplied with the pil carriage have been kept in place during the trials. These sights a not of service pattern and are not adapted to making the accuracy fi ings required by the program, due principally to loose fitting joint These firings under instructions contained in first indorsement O. C 37664–661, June 7, 1904, will be made with a service pattern of ca riage with sights complete to be received from Rock Island Arsena

61. The board also holds for action instructions of thirteent indorsement O. O. 37664–577, July 12, 1904, to determine the velocit of gun recoil and the pressure in recoil cylinder with the servic carriage and the cylinder used in the last 60 rounds with the pilot ca riage; also test of firing handle spring, second indorsement O. C 37664–715, July 20, 1904, and examination of limbers and caisso including the jolting test with chests filled with ammunition, O. C letter 35524–178, July 26, 1904. These tests will be made when th service carriage, limbers, and caisson are delivered at the provin ground.

62. The pilot carriage, sights excepted, is in good working order a the conclusion of the trials, which have embraced 787 rounds fired, i addition to a severe road test at Rock Island Arsenal. The elevatin and traversing gear, trail, and parts of the carriage generally, othe than as herewith noted, have withstood the tests in a satisfactory ma ner. Most of the changes indicated as necessary by the tests of th pilot carriage had been anticipated in the designs prepared for th service model now under manufacture, and the latter should be foun to be strong and enduring while combining in an admirable manne the essential features of the present accepted types of long recoil fie carriage.

Chas. S. Smith,
Lt. Col., Ord. Dept., U. S. Army,
President.
R. Birnie,
Major, Ord. Dept., U. S. Army.
Geo. L. Anderson,
Major, Artillery Corps, U. S. Army.
B. W. Dunn,
Capt., Ord. Dept., U. S. Army.

The Chief of Ordnance, U. S. Army,
Washington, D. C.

35524–179.

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